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ON THE ROLE

OF

THALAMIC AND RETICULAR FORMATION

UPON

THE FREQUENCY RESPONSE ACTIVITIES

OF THE GENERATOR OF

ELECTROENCEPHALOGRAM AND MYOTONOGRAM

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Cerebral EEG activities were elicited by centromedian and midbrain reticular stimulation of low frequency. A high frequency reticular stimulation, by which electrocortical arousal was induced in EEG, followed an inhibitory and augmentative processes to reduce and enhance respectively the flicker activity of low frequency.

It was inferred from the above theoretical and experimental results that servomechanic roles of nonspecific and specific projection system are capable of observing in the EEG "activities." On the same roles in the descending reticular system, some theoretical and experimental evidences were demonstrated in the myotonographic (MT) "activity." (Author)

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ABSTRACT

Theoretical and experimental studies on the "activities" of nonspecific and specific projection systems hidden in the electroencephalogram were conducted from the standpoint of the random process in a stochastic servosystem.

It was verified that EEG "activity" (frequency response) is not only equivalent to the "excitability cycle" of an excitable system, but to an extension of the "spectral sensitibity curve" of the visual system and "response area" of the auditory system.

An augmentative interaction elicited by binocular afferent inflows were found in the EEG activities of specific thalamic level of cats, while not only augmentative but inhibitory interactions were observed in the cerebral visual, somatosensory and association areas.

Cerebral EEG activities were elicited by centromedian and midbrain reticular stimulation of low frequency. A high frequency reticular stimulation, by which electrocortical arousal was induced in EEG, followed an inhibitory and augmentative processes to reduce and enhance respectively the flicker activity of low frequency.

It was inferred from the above theoretical and experimental results that servomechanic roles of nonspecific and specific projection systems are capable of observing in the EEG " activities". On the same roles in the descending reticular system, some theoretical and experimental evidences were demonstrated in the myotonographic (MT) "activity".

CONTENT

1. A STATEMENT OF THE PROBLEM

The research works were performed on the role of the nonspecific (the nucleus centrum medianum) and specific (the lateral geniculate body) thalamic nuclei and the midbrain reticular formation from the point of view of the frequency response activities of the electroencephalogram (EEG) and myotonogram, which are able to consider as random processes in a servosystem (Sato 1962).

2. ANALYSIS OF THE PROBLEM AND AN EXPLANATION OF CONTROLS USED

The frequency response activities, which has already reported in the paragraph 2 of the first quarterly progress report, of EEG in the cerebral visual, somatosensory and association areas, specific and nonspecific thalamic nuclei and midbrain reticular formation were obtained under visual and cutaneous stimulation and electric shock stimulation to the nucleus centrum medianum and reticular formation, wherein frequency responses under a combined stimulation with visual and one of other stimulation were also observed. In most experiments, EEG activities (frequency response) elicited by rhythmic flash stimulation with various frequencies in the range of from 1 to 20 per second were regarded as introducing the control activities.

The roles of the nonspecific and specific thalamic nuclei and reticular formation were analysed by comparing with these frequency response activities each other in the above three cerebral regions under and without influences of the stimulation to the nucleus centrum medianum, lateral geniculate body or midbrain reticular formation.

3. OUTLINE OF EXPERIMENTAL PROCEDURE

Experiments were carried out on cats weighing about 3kg. Under ether anesthesia, the tracheal cannula was put in the trachea and the head was fixed on the Johnson's type stereotaxic instrument (Fig. 3-1), thereafter the skull was opened

Fig. 3-1. Jonson's type stereotaxic instrument for monkey, cat and rabbit.

This instrument was purchased by the Fund of the Rockefeller Foundation (GA. BMR 5893).

carefully with minimum bleeding. Then the ether was blown out by artificial respiration in the electromagnetically shielded room (Fig. 3-2). In the next procedure, the cat was immobilized by an intraperitoneal injection of 20 mg/kg of flaxedil. Oxygen was mixed in the outflowing air from the artificial respirator. In some animals experiments were performed under Nembutal anesthesia (30 mg/kg), whereby artificial respiration was not necessary.

Bipolar depth electrodes made of steel wire or nicrome wire (Gauge 22 and 24) were inserted by the aid of the stereotaxic atlas by Jasper & Ajmon-Marsan (1954) or by Snider & Niemer (1961). Silver ball-tip surface electrodes, which were insulated except at the tip, were monopolarily placed onto the pia mater or dura mater in the areas noted above in the paragraph 2. Reference silver wire electrode was inserted in the neck muscle. The opened cerebral surface was covered with warmed agar gel made from Ringer's solution or with warmed mineral oil. The temperature of shielded room was kept always 28-29°C and a rubber bag filled with hot water was put beneath the abdomen to keep animal in good conditions.

4. EXPLANATION OF INSTRUMENTATION EMPLOYED

As can be seen in the block diagram, illustrated in Fig. 4-1, EEGs, myotonograms (MTs) and the signals of the stimulation were recorded on the recording paper by 8 channel ink-writing electroencephalograph (Fig. 4-2) (San'ei-Sokki Co., Tokyo) and on the 1/4inch magnetic tape (Soni-Tape) simultaneously by 3 channel (Fig. 4-3) or 8 channel data recorder (Fig. 4-4) (Shiroyama-tsûshin) by means of pulse-width-modulation (PWM) method. Occasionally, by applying a double beam cathode ray oscilloscope (Nihonkôden Co.) (Fig. 4-3) and Grass' type long recording oscilloscope camera (Fig. 4-5), the above EEG and/or MT and the stimulation curves were photographed on 35mm film. Rhythmic flash stimulation mono- or
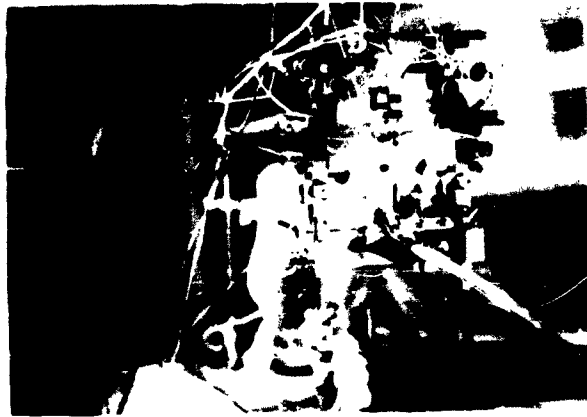
Fig. 3-2. Cat fixed on the stereotaxic instrument ready to the experiment.

Depth electrodes have inserted in the brain and surface electrodes have placed on the exposed pia or dura mater.
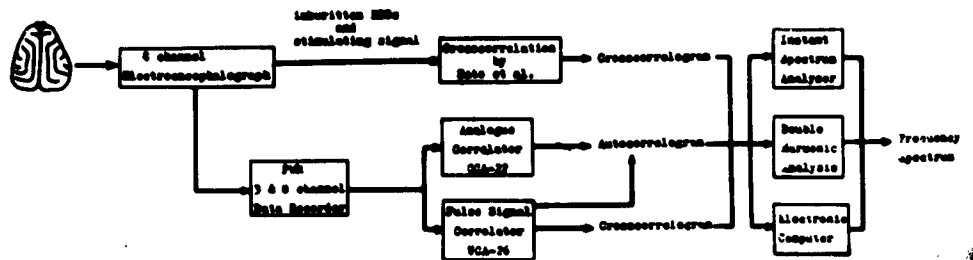
Fig. 4-1A. Blockdiagrams for EEG recording and its data processing.
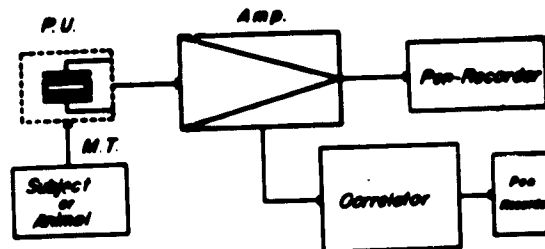
Block Diagram of Recording System

Fig. 4-1B. Blockdiagram for MT recording and its data processing.
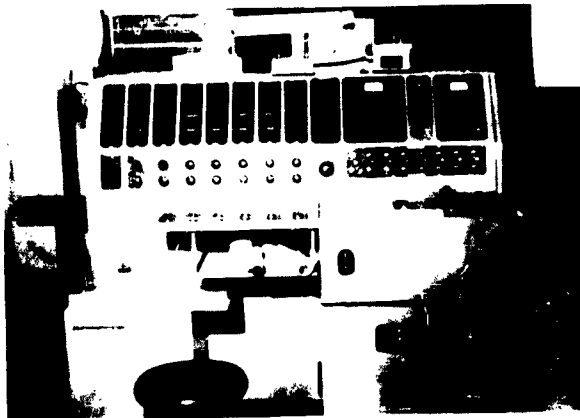
Fig.4-2. 8-channel electroencephalograph.
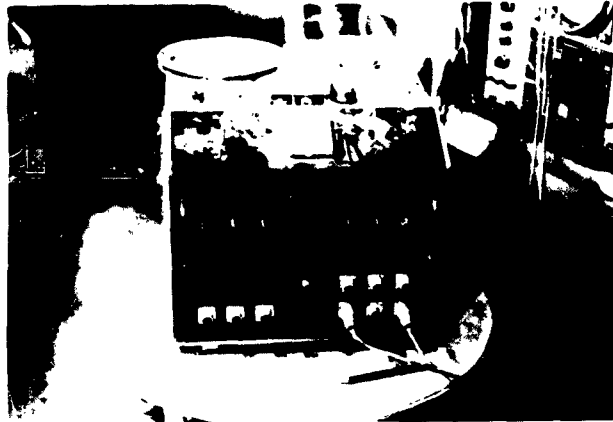
Fig. 4-3. 3-channel analogue data recorder.

On the right upper, a part of double beams cathode ray
oscilloscope is seen. By an electronic switch each of the
double beams is separated in two, so that one oscilloscope
works as a four beams oscilloscope to control the data recorder.
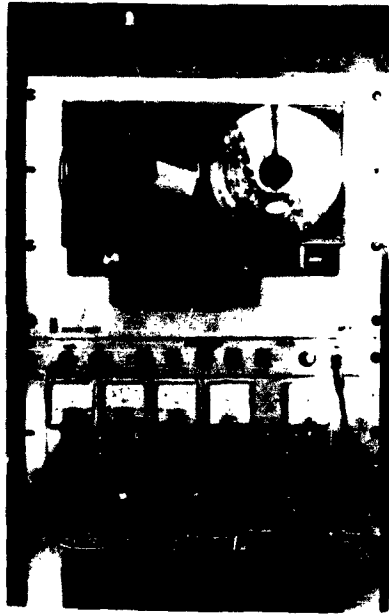
Fig. 4-4. 8-channel analogue data recorder.

By two cathode ray oscilloscopes, illustrated in Fig. 4-3, right upper, simultaneous data recording by means of eight channels are able to control.

Fig. 4-5. Grass' type long recording oscilloscope camera.

This was also purchased by the Fund of the Rockefeller Foundation (GA. BMR 5893).

binocularly was delivered by the strobo-flash valve of the photic stimulator (San'ei-Sokki, Co.). The stimulus intensity of flash was changed by covering the strobo-flash valve with a filter, which has a round window of various diameter (5, 10, 20, 30, 50 and 150 mm). For the purpose of obtaining steady results and of aiming tonic activities, one stimulation was delivered for 60-90 sec., although a far shorter duration (less than 5 sec long in most instances) of a stimulation is generally delivered in the study of the central nervous system. At the end of the experiment the animal's head was perfused with 10 % formalin and the brain was extirpated to embed into 10 % formalin. Celloidin or paraffine sections cut at 10-20 microns were stained by routine Klüver-Barrera staining method (1953). And the location of the depth electrodes inserted in thalamic nuclei and/or reticular formation were checked histologically. Instruments employed in the data processing will be noted in the next paragraph.

5. DATA PROCESSING OF THE EXPERIMENTAL DATA (STATISTICAL ANALYSIS OF DATA TAKEN).

The procedures of EEG recordings and their data processing are illustrated in the block diagram (Fig. 4-1). The following data processings were performed to analyse regular average time- and frequency-patterns from EEG and MT recordings with random irregular fluctuations.

a. Correlation analysis. The data recorded magnetically on 1/4 inch magnetic Soni-tapes were re-recorded on the 1/2 inch endless magnetic Scotch tape for 35 sec to put on the analogue type correlator (CCA-22, Sony Corp.) (Fig. 5-1) or for 60 sec to put on the pulse signal universal correlator (UCA-26, Sony Corp.) (Fig. 5-2). The analogue type correlator (CCA-22) can analyse the wave form in the frequency range lower than about 20-30 c/sec, so that it cannot carry the crosscorrelation analysis between pulse (flash or electric shock) stimulation and EEG or MT. This pulse signal uni-

Fig. 5-1. Analogue type correlator (CCA-22). (Sato, Mimura et al. 1962)

The left box: driving mechnism to rotate the endless tape, which is put on the front surface of the box.

A low and long box in the middle: data recording and reproducing mechanisms.

A low and long box in the middle right: computer mechanism for obtaining auto- and crosscorrelation.

On the right of the computer mechanism, an inkwriting galvanometer to trace correlogram is seen. This correlator was made to analyse oscillation in an earthquake and designed for the first time by us for the purpose of EEG analysis. On the most right and right upper, a part of the stimulator mechanism are seen.
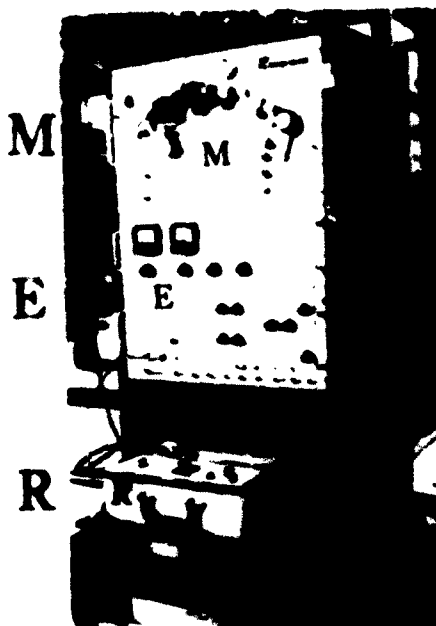
Fig. 5-2. Specially designed pulse signal universal correlator
(UCA-26) (Sato, Mimura et al. 1962).

M: Part of the tape-driving mechanism. Enlarged picture of
   this part is shown in the lower. A and B are reconding
   heads. A' and B' are reproducing heads.
E: Part of the electronic calculation.
R: Heating pen type recorder to record correlograms.

versal correlator (UCA-26) can perform not only analysis under
the same principle as the analogue type correlator, but also
can compute the auto- and crosscorrelograms of one and two
pulse signal time series respectively. In addition, this
correlator can perform also the crosscorrelation analysis of
the pulse stimulation and EEG or MT, because it was designed
to perform our methods for obtaining the average response
time-pattern (Sato et al. 1962), crosscorrelation analysis
(Sato et al. 1962) and autocorrelation analysis (Sato et al.
1962).

Autocorrelation analysis was performed by the analogue
type correlator (CCA-22), while crosscorrelation analysis
between rhythmic stimulation and the EEG recording was computed
by the pulse signal universal correlator (UCA-26), by which
autocorrelograms were also obtained if necessary.

Numerical crosscorrelation analysis was performed in the
following procedures. Inkwritten or photographed EEG and/or
MT curves and signal of the stimulation respectively obtained
by the electroencephalograph or the Grass' type oscilloscope
camera (Fig. 4-5) and cathode-ray oscilloscope were copied
by handwriting on the transparent graph papers or recopied
photographically on special bromide papers by the quick copy
(Fuji Co.). A zero-axis (base line) of every EEGs or MTs
was selected in the center of the oscillating fluctuation in
each of them and the ordinates of the EEG or MT were sampled
digitally at every one millimeter or every one half millimeter,
which corresponds to 1/60 and 1/120 sec respectively, because
the paper speed for inkwriting EEGs by the electroencephalograph
was 60 mm/sec The crosscorrelogram between the time series
of EEG obtained by the above noted procedures and the stimu-
lation were computed by our simple and practical method (Sato
et al., 1962).

b. Frequency analysis. Auto- and crosscorrelograms re-
corded by the pulse signal correlator (UCA-26) and some of
autocorrelograms traced by the analogue type correlator (CCA-22)

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were recorded under the magnetic BD recording (boundary dis-
placement type recording) onto 1/2 inch magnetic tape by a
specially deisgned pantagraph (Fig. 5-3). Frequency spectra
of them were recorded by the instant spectrum analyser (Sony
Corp.) (Fig. 5-4A), which was newly designed for EEG data
processing (Uemura 1960). The principle of this new analyser
is as follows: The magnetic 1/2 inch tape (Fig. 5-4B, T), onto
which a correlogram of EEG was drawn by BD recording, is let
to contact with the rotary magnetic reproducing head (Fig.
5-4B, RH) and the rotary head (H) is led to rotate by an
electric motor. When the head runs rubbing the lower surface
of the tape with its velocity of "v" cm/sec, the oscillating
electric current with a frequency of "f" c/sec will be repro-
duced from the head (H) under the following relationship

(5.1) $f = vf_r$,   i.e. $f_r = f/v$

where "f_r" is the frequency of the oscillation recorded onto
the tape (T). The oscillating current of "f" c/sec flows
in the first amplifier A_1 to amplify and to flow in the filter
(F). If the frequency of the filter is "f_0" c/sec, then

(5.2) $f_r = f_0/v$,

Thus, only the current of f_0 c/sec in the output current of
the amplifier A_1 can exclussively pass the filter (F). The
higher the rotating velocity of the head (H) is, therefore,
the slower oscillation in the drawn waves onto the tape will
be analysed and vice versa. The analysed oscillating current
was rectified to obtain a direct current proportioned to its
amplitude. The rectified current is amplified again by the
D.C. amplifier (A_2) suitably to record the frequency spectrum
on the special recording paper (Nikko-Recording paper) by the
heating-pen-type recorder (P).

     When the head (H) is set in motion, it rotates with in-
creasing velocity to reach a maximum speed, and then the head
loses its speed gradually. In the former half sensitivity
for analysis is checked and adjusted and in the later half the

Fig. 5-3. Specially designed pantagraph for BD recording
the wave form (EEG or MT curve and/or their correlograms) on
1/2 inch magnetic tape.

The curve will be drawn on a scale of one-third of the
original wave form in its length and amplitude. The reduced
curve drawn on a tape cannot be visualized in itself, but
can be by spattering special iron powder slightly onto it
to check.
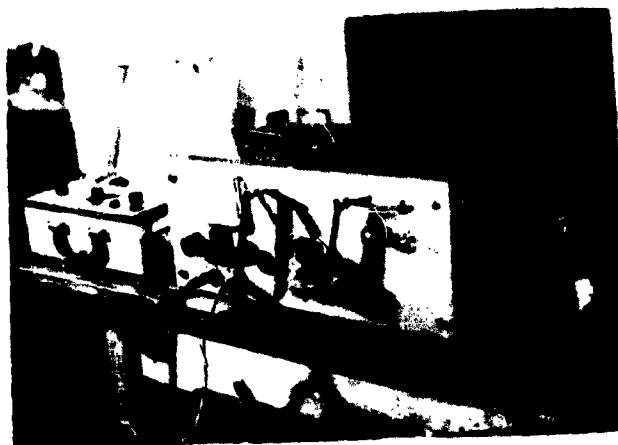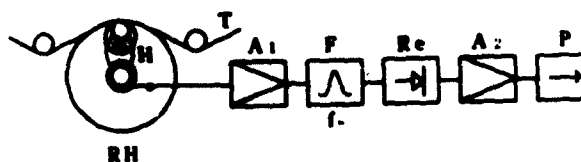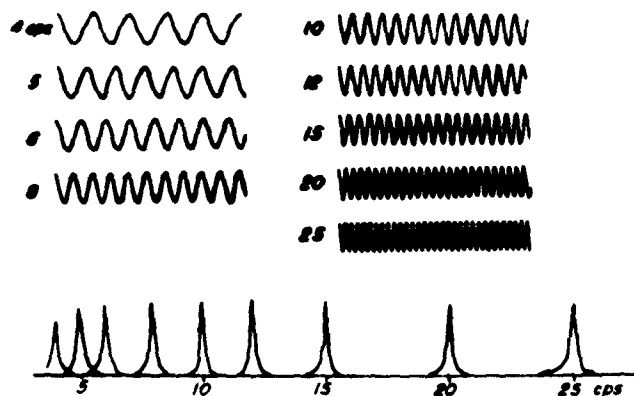
Spectrum Analyser

Fig. 5-4

(See next page)

Fig. 5-4. The instant spectrum analyser specially designed
for EEG analysis (Uemura, 1961,a, b), which was originally
asked to make by us.

> A: General view of the instant spectrum analyser.
> B: Block diagram of the analyser.
>> The tape (T), onto which the wave form was
>> drawn by the special pantagraph (Fig. 5-3), is
>> attached to the rotating head (H). When the head
>> is set in motion with gradually increasing speed to
>> a maximum and then decreasing speed, the frequency
>> spectrum will be traced by the heating pen type
>> pen-recorder (P) on the special paper (Nikko-recording
>> paper).
> C: Upper curves are sinoidal waves of various frequencies
>> (cycles per second).
>> ⋯⋯ves are their peaks analysed by the
> analyser.

frequency spectrum is recorded on the paper.

In some of the autocorrelograms and crosscorrelograms, which were respectively traced by the analogue type correlator (CCA-22) or by the pulse signal correlater (UCA-26) and/or computed by our method noted above, their ordinates were sampled to form digital time series by the above noted method and the time series were punched on the data tapes by the 6-unit perforator (Kurosawa-Tsûsin Co., and or Okidenki K.K.) (Fig. 5-5, A and B) and sent to the administrator of the electronic computer in Tokyo and their frequency spectra were computed by means of the program of 201 ordinates harmonic analysis and the results were sent back to our laboratory. In some of the time series sampled from the above auto- and crosscorrelorams Kobayashi's double harmonic analysis (1953, 1955) were also applied in our laboratory to obtain their frequency spectra.

c. Frequency response analysis. An important relation between the power spectrum of the rhythmic experimental stimulation with 'f' per sec, that of the crosscorrelation function between the experimental stimulation and the EEG tracing during the stimulation and the EEG generator activity or the frequency response of the generator have already reported in the Paragraph 2 of THE FIRST QUARTERLY PROGRESS REPORT, i.e.

$$(5.3) \qquad X^2(e;f) \cdot G(e;f) = \overline{\Phi}_{ey}(f),$$

where $X(e;f)$ and $\overline{\Phi}_{ey}(f)$ are respectively the power spectra of the experimental stimulation and the crosscorrelation function and $G(e;f)$ is the frequency response of the generator, or the power spectrum of "threshold-impulse-response" of the generator due to an experimental impulse stimulation.

As the rhythmic experimental stimulation with various frequencies were delivered always with a finite constant intensity in any frequency, the power spectrum of the stimulation is able to regard as always constant in every frequencies of all the stimulations, i.e.

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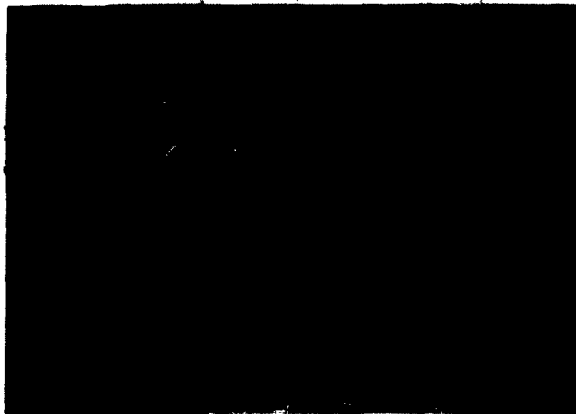
Fig. 5-5A. 6 unit perforator (Kurosawa-Tsûshin).

Fig. 5-5B. 6 unit perforator (Oki-Electric Industry Co.).

(5.4) $X(e;f) = K_e$,   (K_e: const.)

Therefore,

(5.3') $K_e^2 G(e;f) = \Phi_{ey}(f)$.

Consequently, the property of the generator activity (frequency response), $G(e;f)$, would be revealed by the power spectrum of the crosscorrelogram of the experimental stimulation and the EEG tracing during delivery of the stimulation. For convenience sake, therefore, the above crosscorrelogram $\Phi_{ey}(f)$ is usually nominated as the frequency response in place of $G(e;f)$ itself.

The frequency response activities were obtained in the following procedures.

(1) Data sampling and crosscorrelation analysis. An ink-written or photographed EEG tracing with the signals of the experimental rhythmic stimulation was traced by handwriting on the transparent graph paper when the digital numerical crosscorrelation analysis (Sato et al., 1962) noted above is applied, while magnetically recorded EEG and rhythmic pulse series of the stimulation, which were recorded onto 1/4 inch tape by the 3-channel or 8-channel data recorder, were re-recorded on the endless 1/2 inch Scotch tape by the data recorder and the pulse signal correlator (UCA-26) to obtain the crosscorrelograms of the rhythmic stimulation and EEG by means of the pulse signal correlator.

Thus, the crosscorrelograms of the stimulation of various frequencies and the EEG recordings were obtained (Fig. 5-6S and 5-7B).

(2) Frequency analysis of crosscorrelograms. Wave forms of the crosscorrelograms were recorded magnetically onto 1/2 inch tape by the specially designed pantagraph (Fig. 5-3) by means of boundary displacement type magnetic recording (BD recording) and then the amplitude spectrum of a crosscorrelogram was recorded by the instant spectrum analyser (Fig.5-7,C). The ordinates of a crosscorrelogram traced by the pulse signal

R   **S**
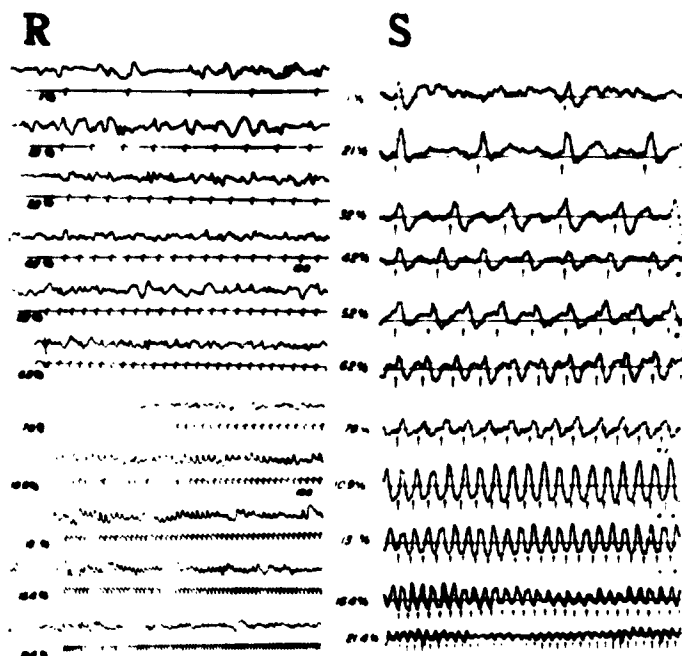
Fig. 5-6.I. Diagramatic illustration of procedures for obtaining the frequency response.

R: EEGs led from cerebral auditory area of a cat and the curves of rhythmic click stimulations with various frequencies (1, 2.1, 3.2, 4.2, 5.2, 6.2, 7.8, 10.9, 13, 16.4 and 21.4 per second).

S: Crosscorrelograms of the click stimulation and EEG, which were computed by our method (Sato, Honda et al. 1962). Arrows indicate the time points delivered the click.
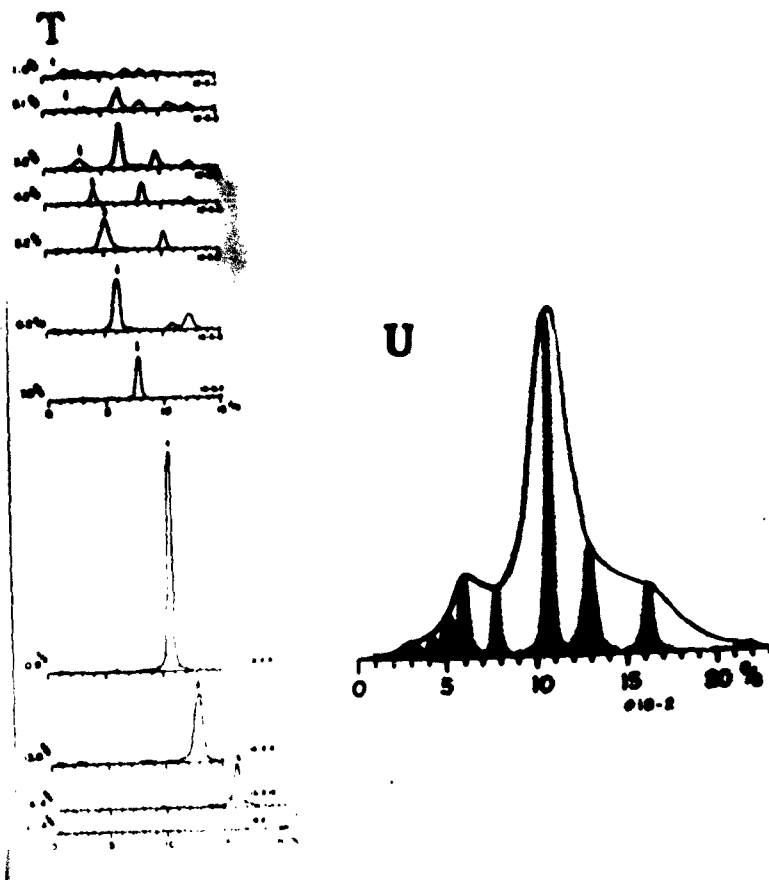
Fig. 5-6.II. Diagramatic illustration of procedures for obtaining the frequency response.

T: Power spectra of the above crosscorrelograms, which were computed by the electronic computer. Arrows pointing downward locate at the stimulating frequency.

U: Frequency response. Abscissa is the stimulating frequency and ordinate is the peak height at the stimulating frequency.
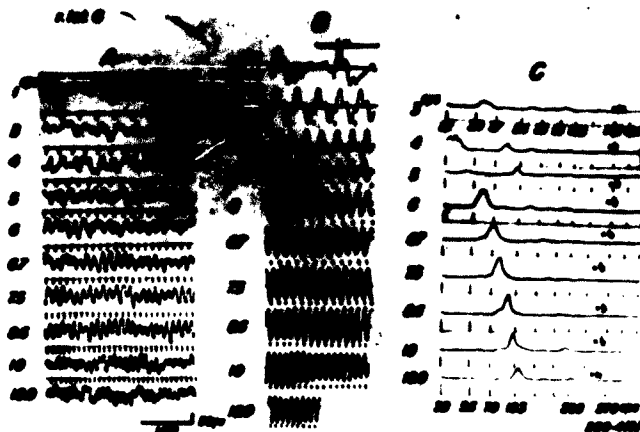
Fig. 5-7. Procedures for obtaining the frequency response.

A: curves of rhythmic flash stimulation and EEG led from cerebral visual area.

B: crosscorrelograms of the stimulations and EEGs, which were calculated by our method (Sato, Honda et al. 1962).

C: frequency spectra of the crosscorrelograms, which were traced by the instant frequency analyser (Fig. 5-4).

The numbers on the left of curves in A, B and C indicate the stimulating frequency per second.

correlator were sampled digitally in every a finite time interval to form a time series, when its power spectrum was obtained by the electronic computor in Tokyo or by the method of double harmonic analysis. The power spectra of the above crosscorrelograms were obtained, therefore, by the instant spectrum analyser, by the electronic computer in Tokyo or by double harmonic analysis (Kobayashi 1953, 1955).

(3) _Determination of the amount of the average EEG responses_. In the amplitude spectra and/or the power spectra of the above crosscorrelograms, a peak located at the stimulating frequency appeared to show the basic response to the rhythmic stimulation (Fig. 5-6,T, Fig. 5-7,C) and its height indicates the amount of the EEG response in average, that is to say, $\overline{\Phi}_{ey}(f)$ in (5.1').

(4) _Plotting the frequency response behavior_. Consequently, taking the stimulating frequency as abscissa and the above peak heights as ordinate the frequency response behavior will be able to plot (Fig. 5-6,U).

6. CONCLUSIONS DRAWN

Not only experiments on the roles of the thalamic nonspecific and specific nuclei and reticular formation upon the "activity" (frequency response) of the generators of electroencephalogram (EEG) and myotonogram (MT) were conducted, but also physiological significances of the EEG "activity" (frequency response) and/or MT "activity" were studied from the theoretical point of view of random precess in a stochastic servosystem.

It was revealed that the "activity" (transforming action) has an equivalent significance not only to the "excitability cycle" ("recovery curve" of the excitability), but also to an extension of the "response area" in the auditory system and the "spectral sensitivity curve" in the visual system. It was inferred, therefore, that the amount of the interaction between the effects of two afferent inflows upon the "activity" in a

portion of cerebrum, subcortical system and others in the
central nervous system can be measured by the difference be-
tween the average frequency-patterns (frequency spectra) of
the "activity" induced by the combination of the two afferent
stimulations and the summation of those of each "activity"
induced by the two afferents. An augmentative or facili-
tatory interaction will be taken place, when the former average
frequency-pattern is larger than the summatione of the latter
two average frequency-patterns, while an inhibitory interaction
will be taken place, in the instance of the reverse relation
to the above. And no interaction will be induced when no
difference was observed between the amount of the above two
average frequency-patterns.

A prominant augmentative bilateral interaction of EEG
was newly found in the lateral geniculate body (thalamic
specific nucleus). This result was different from the one
revealed by Bishop, Burke et al. (1958) in the excitability
cycle. As well as an augmentative effect in the interaction
of the mono- or binocular photic stimulation and unilateral
lateral geniculate stimulation, an inhibitory one was also
obser'ed. It would be able to infer, therefore, both in-
hibitory and augmentative activities in the level of lateral
geniculate body.

By obtaining the autocorrelegrams of the cerebral EEGs
and the crosscorrelograms of the stimulation and the EEGs,
the average responses of EEG elicited by a low frequency
midbrain reticular stimulation were conspicously observed.
And those induced by low frequency centromedian stimulation
were also the same. By such a high frequency midbrain re-
ticular stimulation, that evokes electrocortical arousal in
cerebral EEGs, EEG response of photic flicker with a low
frequency was inhibited in a cerebral region, while it was
augmented in a different region. Not only an inhibitory
but an augmentative process in the cerebral cortex would be,
therefore, capable of considering during electrocortical

arousal state. Consequently, a new concept on the ascending reticular activating and/or inhibitory systems concerning the EEG responses would be possible to consider, though more precise various observations and results on the EEG response "activities" should be pile up to solve this problem.

On the central innervations, i.e. descending reticular influences upon the myotonogram (MT) activity, some evidences of inhibitory and augmentative effects of the midbrain reticular formation were observed.

7. IMPLICATIONS OF CONCLUSIONS

a. Interactions in the EEG responses to mono- and binocular photic flickering stimulation.

Many evidences, which demonstrate photic flickering flash stimulation are suitable to observe the human EEG activity, have been reported by Sato, Sato et al., Mimura and Kitajima. In our research experiments, therefore, EEG responses in the cerebral cortex elicited by mono- and binocular stimulation of flickering flashes were also observed.

Let here $x(t)$ be the stimulation to cause the EET activity in general and $_lx_1(t)$ and $x_0(t)$ be the left monocular stimulation and the natural stimulation with respect to time "t" respectively, then $x(t)$ be

$$(7.1) \qquad x(t) = x_0(t) + {}_lx_1(t),$$

as reported in the paragraph 2 of the Third Quaterly Progress Report. And

$$(7.2) \qquad x(t) = x_\bullet(t) + {}_rx_1(t),$$

when the monocular flash stimulation is delivered to the right eye. It is also obvious that

$$(7.3) \qquad x(t) = x_0(t) + {}_lx_1(t) + {}_rx_1(t)$$

when the binocular stimulation is delivered.

Let the power spectra of the EEG responses due to the

stimulations expressed by (7.1), (7.2) and (7.3) respectively by $_1Y_{01}(f)$, $_rY_{r1}(f)$ and $_{1r}Y_{01}(f)$, then the interaction between the left and right monocular stimulation will be expressed in the following $C_{1r}(f)$

(7.4) $\qquad C_{1r}(f) = {}_{1r}Y_{01}(f) - {}_1Y_{01}(f) + {}_rY_{01}(f),$

as reported in the Third Quarterly Progress Report (see (2.10-1) in page 6).

When

(7.5) $\qquad C_{1r}(f) > 0,$

an augmentative interaction is revealed, while when an inhibitory interaction took place

(7.6) $\qquad C_{1r}(f) < 0$

and when

(7.7) $\qquad C_{1r}(f) = 0,$

no interaction would result.

The interactions elicited in the EEG response due to the left and right monocular flickering stimulations with 10 /sec frequency were observed, because these interactions will be important for basic or control activity to make clear the influences of nonspecific and specific thalamic nuclei and reticular formation upon the cerebral EEG activities. In the inkwritten or photographed EEG records themselves, the EEG responses were distorted and/or masked by irregular fluctuations, which would be irrelevant to the experimental stimulation, while in the autocorrelograms of the EEG recordings, as illustrated in Fig. 7-1,A, far more regular time-pattern were observed, since irregular fluctuations were eliminated by data processing of autocorrelation analysis. As can be seen in Fig. 7-1,A and B, the amount of EEG responses by a same stimulation in a region were usually not the same each other in the left and right side.
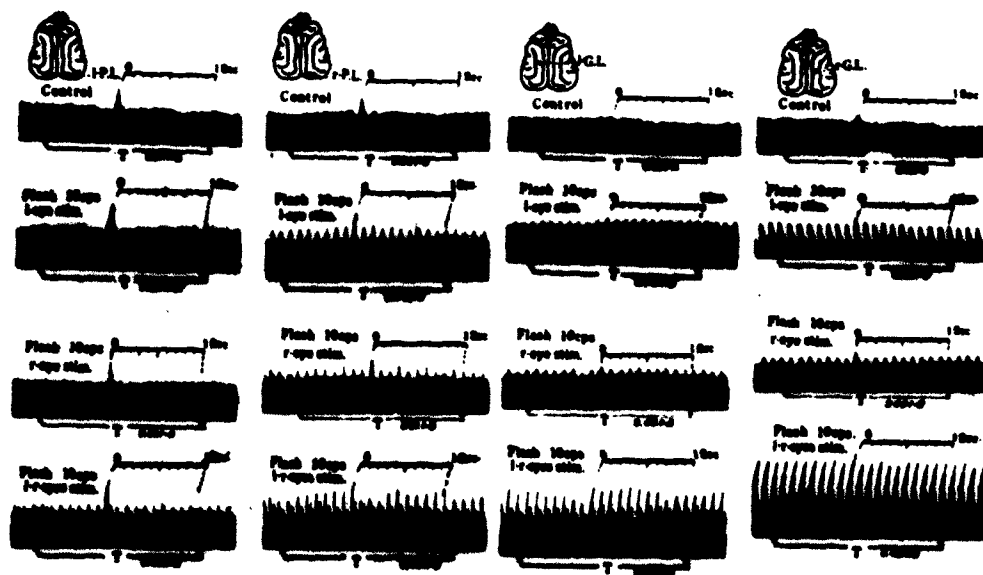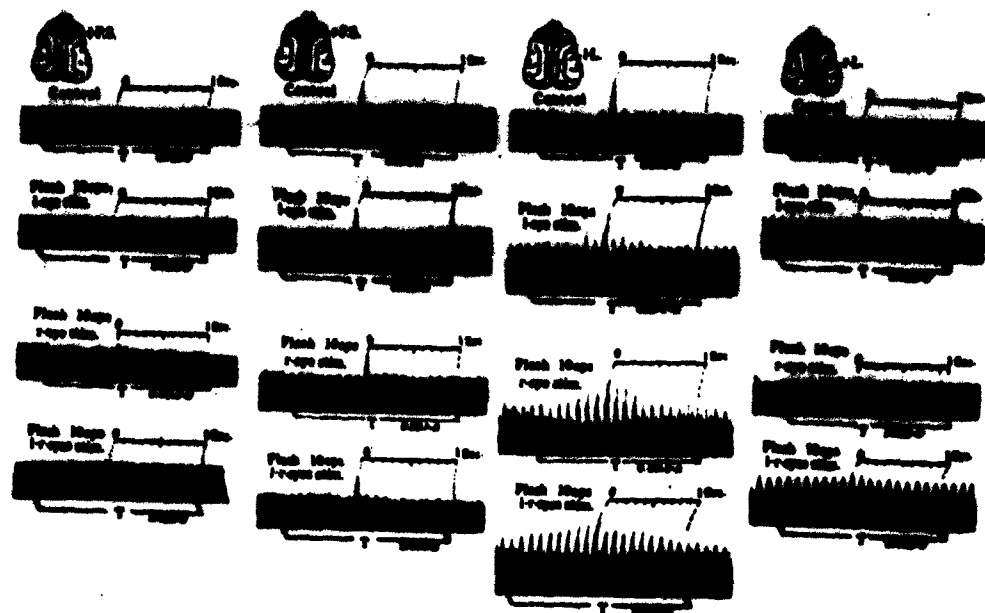
Fig. 7-1A. Autocorrelograms of EEGs before and during monocular photic flickering stimulation of 10 /sec. (See next page)

Fig. 7-1A. Autocorrelograms of EEGs before and during monocular photic flickering stimulation of 10 /sec.

'l' and 'r' show left and right.   P.S., L, P.L., and G.L. indicate respectively the posterior sigmoid gyrus, lateral gyrus, posterior portion of lateral gyrus and lateral geniculate body.

Abbreviations in the cat's brain sketch show the regions, from which EEGs were led.   Four autocorrelograms from the top to downward in each region were obtained from the EEGs during without any experimental stimulation (Control), with the left monocular; right monocular, and binocular flickering flash stimulations of 10 /sec respectively.

Fig. 7-1B.   Frequency spectra of the autocorrelograms in Fig. 7-1A. (See next page)

Abbreviations are the same as those in Fig. 7-1A.   On the left in each frequency spectra of the autocorrelograms during left(l) and right(r) monocular stimulations are illustrated and at the frequency of 10 /sec the summation of two peaks of the EEG responses elicited by two monocular stimulations is indicated.   On the right the spectrum of the autocorrelogram during binocular (l + r) stimulation.
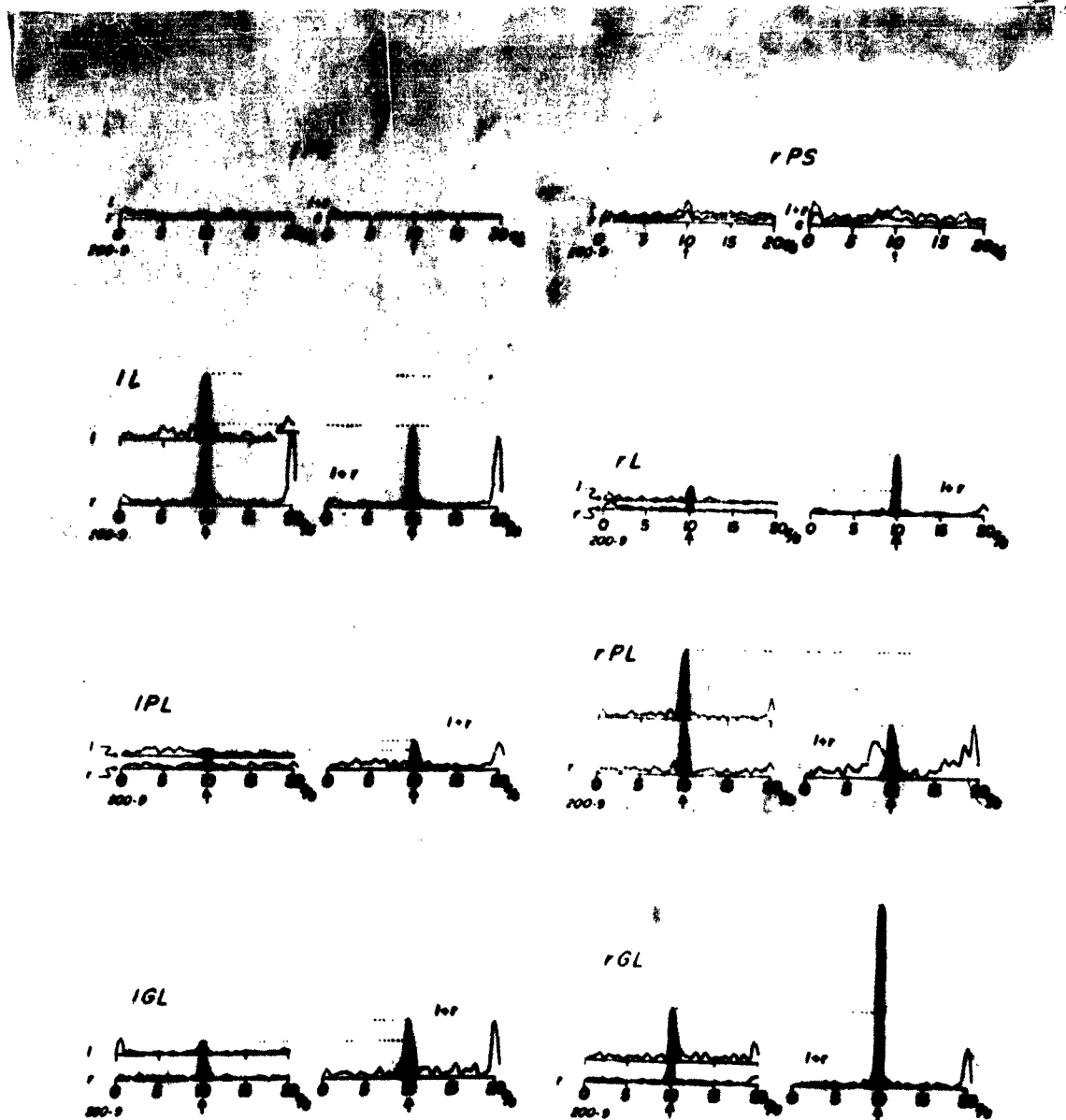
Fig. 7-1B. Frequency spectra of the autocorrelograms in
Fig. 7-1A. (See page 29)

A rhythmic oscillations of the stimulating frequency in the autocorrelograms (Fig. 7-1,A) and the peaks located at the stimulating frequency in the spectra (Fig. 7-1,B) will be able to consider as the EEG responses elicited by the flickering visual stimulation, because no or very little oscillation with the same frequency was observed in the autocorrelograms of the control EEGs without the experimental stimulation. A slight EEG response was observed in the posterior sigmoid gyrus (PS) (somato-sensory area), while a prominent one was elicited in the lateral gyrus (L) (visual area). In the posterior region of the lateral gyrus (PL), however, EEG response was weaker than that driven in the middle portion of the lateral gyrus. In the right lateral geniculate body (rGL), EEG response elicited by contralateral monocular stimulation was higher than that by ipsilateral stimulation. The response due to binocular stimulation was higher than the summation of the response to contralateral and ipsilateral monocular stimulation respectively.

Consequently, a facilitatory interaction between the EEG activities due to ipsi- and contralateral afferent inflows was observed in the lateral geniculate body. Net only the response of 10 /sec frequency, but that of 20 /sec (the first high harmonic frequency) was also observed in the frequency spectra and it was elicited more prominently by the binocular stimulation than by the monocular stimulations to show a facilitatory interaction. In several autocorrelograms double or triple response time-patterns were observed, in all of which a peak at 20 c/sec appeared. It is to be noted, therefore, from this fact that the peak in the high harmonic frequency of the stimulating frequency would be not always the EEG response of high harmonic frequency, but it verify the existence of the two or three different responses of the stimulating frequency.

In the left posterior sigmoid gyri (LPS) the EEG response of 10 /sec and 20 /sec were very slight, while in the

right gyrus (rPS) a very low peak only appeared at the stimulating frequency (10 /sec) by ipsi- or contralateral monocular stimulation. By binocular stimulation, no evidence to suggest interactions were observed in the both posterior sigmoid gyri (lPS and rPS).

In the lateral gyri (L), a prominent facilitatory interaction in the EEG response of 10 /sec, which was driven by binocular flicker stimulation, was observed in the right gyrus (rL), whereas in inhibitory interaction was revealed in the left lateral gyrus (lL). Though a facilitatory and inhibitory interactions were also observed in the posterior region of the lateral gyri (PL), they were elicited in the opposite side to those in the lateral gyri (L), i.e. they appeared in the left and right side respectively.

It would be verified from the above evidences that the afferent inflows from ipsi- and contralateral optic pathways will converge at least in a portion of the lateral geniculate body to evoke facilitation in its activity, which in the cerebral visual area they will converge to induce not only a facilitation, but also an inhibition of the cortical activities. Consequently, a more complicate (higher) activities will be able to occur in the cerebral cortex than those in the specific thalamic nucleus. And the evidence of facilitatory interaction in the lateral geniculate body suggests that this nucleus plays not only a role of relay station, but also acts as a modulating center.

Though it is well recognized that the cerebral visual area of a cat occupy the lateral gyrus (the marginal gyrus), which lies long in the medial margin to form the great longitudinal fissure between the bilateral gyri. So that it was necessary to verify the local difference in the EEG response to photic visual stimulation. It would be better to observe the crosscorrelograms of the stimulation and the EEG recordings and their amplitudes or power spectra, than to observe the autocorrelograms of the EEG recordings and their spectra,

because in the former irrelevant activities will be eliminated
exclusively, while in the latter irrelevant activities will be
able inclusive in average.

In Fig. 7-2, crosscorrelograms of the photic flicker
stimulation of 10 /sec to right eye and the monopolar EEG re-
cordings in various portions of the right lateral gyrus, which
were traced by the pulse signal correlator, and their ampli-
tude spectra obtained by the instant spectrum analyser were
illustrated.   It was clearly verified that the prominent EEG
responses were induced in the posterior half portion (regions
5-7 in Fig. 7-2) of the lateral gyrus, while only feeble or
no responses were observed in the former half portion (Fig. 7-2,
regions 1-3).

In the posterior portion of lateral gyrus (regions 6 and
7 in Fig. 7-2) and middle portions (regions 4 and 5), in which
clear responses were induced, two or three potentials were
evoked by one flash in 10 /sec flicker stimulation.   In the
region, in which most conspicuous response were observed, three
potentials were clearly recognized in every instance of ipsi-
and contralateral monocular stimulation and binocular stimu-
lation, while in the other regions, except the response to the
ipsilateral stimulation in the region 5 and 4, the second and the
third potentials were fused to one wave form.

The response time-patterns (crosscorrelograms) elicited
by binocular stimulation were more prominent than those by
contra- and ipsilateral monocular stimulation.   These seemed
to be occured an augmentative interaction.

In the frequency spectra of these crosscorrelograms, how-
ever, the peak height $_{lr}Y_1(f_e)$ at the stimulating frequency
(f_e = 10 /sec) in the region 5 and 6, which was elicited by
binocular stimulation, was lower than the summation of those
elicited by the afferent inflows via crossed and uncrossed
monocular optic pathways respectively, i.e.

(7.8) $_{lr}Y_1(f_e) < {_l}Y_1(f_e) + {_r}Y_1(f_e)$

Fig. 7-2. Crosscorrelograms of photic flickering stimulation and EEGs in various portions of lateral gyrus and their frequency spectra.

Upper: Crosscorrelograms computed by the pulse signal correlator. Two marks are beneath the lowest correlograms, by which the two locations of flash stimulus repeated by 10 /sec flicker are indicated.

Lower: Frequency spectra drawn by the instant frequency analyser.

l-EYE, r-EYE and l r-EYES show respectively left and right monocular, and binocular stimulations.

where $_l Y_1(f_e)$ and $_r Y_1(f_e)$ are respectively the peak height induced by left and right monocular stimulation and f_e is the frequency of the experimental stimulation. Consequently, an inhibitory interaction would be hidden in the crosscorrelograms in the cerebral visual area and it will be difficult to evaluate from the crosscorrelograms themselves.

In the posterior lateral gyrus (region 7), however, the peak height of the response due to binocular stimulation was the same as the summation of those due to contra- and ipsilateral monocular stimulation respectively, i.e.

$$(7.9) \qquad _{lr}Y_1(f_e) = {}_l Y_1(f_e) + {}_r Y_1(f_e)$$

No interaction was observed, therefore, in the posterior lateral gyrus. In the first high harmonic response with the frequency of 20 /sec in the region 7, 6 and 5 no interaction was also observed, since the above relation (7.9) was verified in these regions. On the region 4, however, inhibitory interaction was revealed in the harmonic response.

In all frequency spectra obtained from those crosscorrelograms, in which double or tripple responses to one flash stimulus were observed, a peak at the first high harmonic frequency (20c/sec) appeared except in the spectrum of the response driven by right monocular stimulation in the region 5. This evidence made sure of the already noted speculation in the above that the peak at high harmonic frequency of the stimulating frequency will indicate double and/or tripple response to one stimulus in the rhythmic stimulation.

b. Interactions between the EEG responses due to retinal and specific thalamic afferent signals. Interactions in the EEG responses driven respectively by right monocular photic flickering stimulation and rhythmic electric shock to the right lateral geniculate body in the bilateral posterior sigmoid gyri (PS), lateral gyri (L), posterior lateral gyri (PL) and left lateral geniculate body (lGL) were observed (Fig. 7-3,A

and 2). The frequency of the both stimulations were 8 /sec.

EEG responses elicited by right moncular stimulation, in
the bilateral posterior sigmoid gyri (lPS, rPS) were little
(Fig. 7-3 A, B), while by the stimulation to right lateral
geniculate body the responses were induced in the ipsilateral
gyrus.   In the other ipsilateral gyri (rL and rPL) also ob-
serve the responses.   This response was remarkable in the
right posterior lateral gyrus (rPL).   A peak of the first
high harmonic responses of 16 /sec also appeared in the power
spectra (Fig. 7-3, B) of the ipsilateral gyri to suggest two
potentials due to one electric shock (Fig. 7-3, B rPL), as
already pointed out.   On the other hand, no response was
elicited in the left lateral geniculate body (lGL).   The re-
sponse due to right lateral geniculate stimulation in the
bilateral lateral gyri (lL, rL) were slighter than those in
the posterior lateral gyri.

The first high harmonic responses due to right monocular
flickering stimulation were yeilded more remarkably in the
spectra at the frequency of 16 /sec than the responses at the
basic frequency (8 /sec).   In the corresponded autocorrelo-
grams (Fig. 7-3, A), however, the most prominent responses
were observed at every 1/8 sec and lower one or two responses
intervened between two adjacent basic responses to form re-
spectively double or tripple response of the stimulating fre-
quency already noted in the former section (Fig. 7-1 and 2).
The most enhanced EEG responses due to the monocular stimu-
lation were observed in the contralateral (left) lateral gyrus
(lL), the next was in the ipsilateral (right) lateral gyrus (rL).
No responses were elicited in the bilateral posterior lateral
gyri (lPL, rPL) and in the left posterior lateral gyrus, while
in the left lateral geniculate body a slight response was in-
duced,

In the autocorrelograms (Fig. 7-3, A), the average re-
sponse time-pattern due to the combined stimulation of the

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Fig. 7-3A. Autocorrelograms of EEGs during monocular and lateral geniculate stimulations of 6 per sec. (See next page)

Fig. 7-3A. Autocorrelograms of EEGs during monocular and lateral geniculate stimulations of 8 per sec.

Abbreviations see Fig. 7-2A. In each regions, four autocorrelograms of EEGs during no experimental stimulation (left upper, control), right monocular flash (right upper), right lateral geniculate electrical stimulation with 2 volts 10 ms (lower left, r-GL) and the synchronous combination of the two stimulation (rGL + Flash, lower right) are illustrated.

Fig. 7-3B. Frequency spectra of the autocorrelograms in Fig. 7-3A. (See next page)

Abbreviations see Fig. 7-2B. On the left in each regions the spectrum during right geniculate stimulation ((rGL)) is painted black, while that of during right monocular stimulation ((r Eye)) is summated in white on the black-painted spectrum. On the right the spectrum during the combined stimulation (r Eye + rGL) in white is summated on that of the control without no stimulation, which is indicated by dotted area. Arrow pointing downward is the location of the stimulating frequency of 8 c/sec.
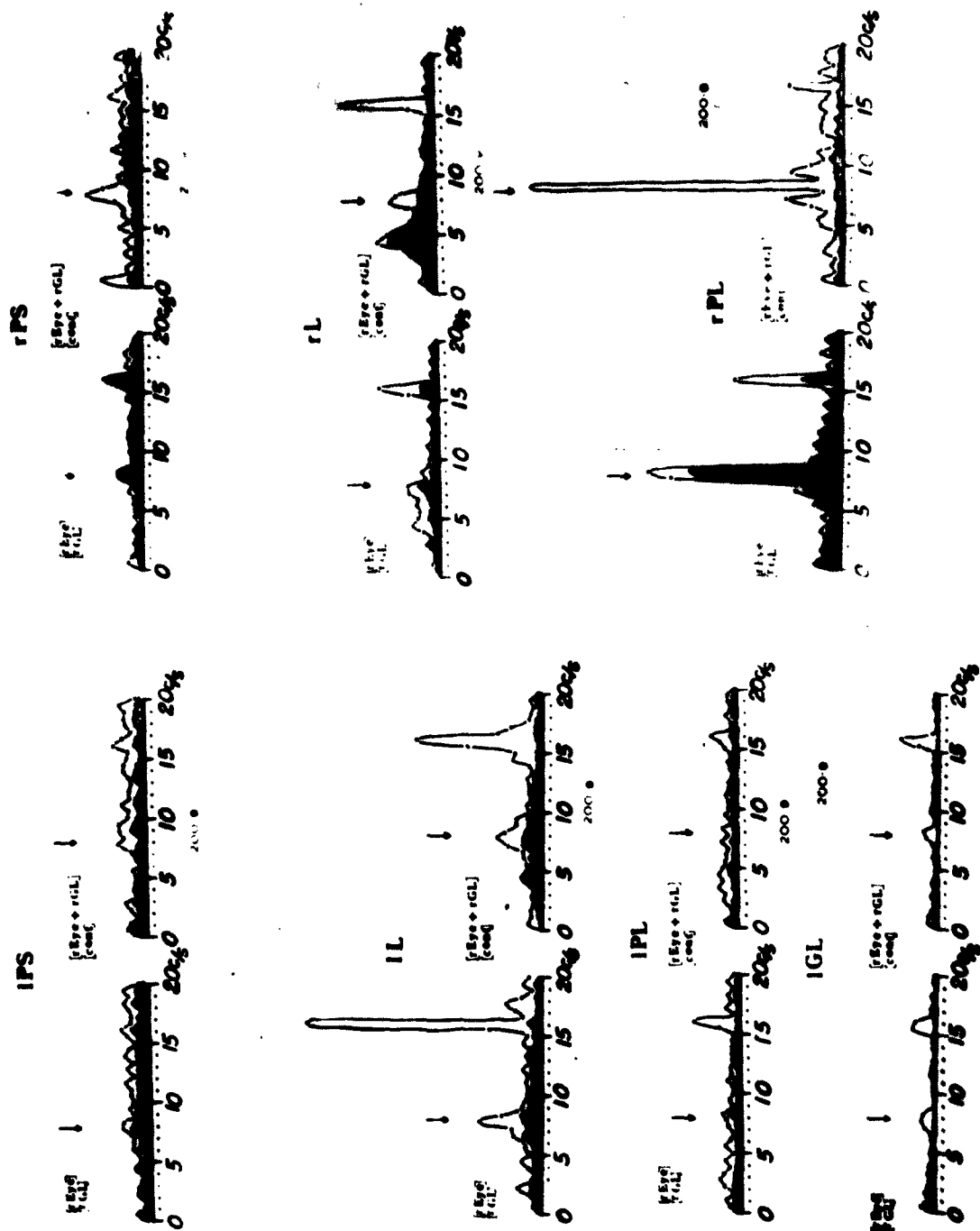
Fig. 7-3B. Frequency spectra of the autocorrelograms in Fig. 7-3A. (See page 38)

right monocular stimulation and the stimulation to the right lateral geniculate body was more prominent in the bilateral posterior sigmoid gyri (lPS, rPS), right lateral gyrus (rL), right posterior lateral gyrus (rPL) and left lateral geniculate body than each or one of the average response time-patterns elicited by the stimulation to monocular and to the geniculate body respectively, while lesser in the left lateral gyrus (lL) and left posterior lateral gyrus (lPL). Consequently a facilitatory interaction in the former and an inhibitory interaction were suggested.

It was observed in the power spectra (Fig. 7-3, B) that in the contralateral (left) lateral gyrus (lL), posterior lateral gyrus (lPL) and lateral geniculate body (lGL), the summation of the EEG response of 8 c/sec due to right monocular stimulation and that due to right lateral geniculate stimulation was higher in peak height as that due to the synchronously combined one of these two stimulations. The above summation of the peak at the first high harmonic EEG response of 16 sec was also higher than that due to the combined stimulation in the left lateral (lL) and posterior lateral gyri, while lower in the left lateral geniculate body (lGL). So that an inhibitory and facilitatory interactions of the high harmonic responses were observed respectively in the contralateral visual areas (lateral and posterior lateral gyri) (lL, lPL) and in the contralateral lateral geniculate body (lGL).

In the ipsilateral (right) cerebral heminsphere (right posterior sigmoid, rPS, lateral, rL, and posterior portion of lateral gyri, rPL), the summation of the above EEG responses of 8 c/sec was lower than the response due to the combined stimulation. This difference was the most remarkable in the right posterior lateral gyrus. (rPL), while reverse evidences concerning the response of high harmonic frequency (18 c/sec) were observed in the posterior sigmoid gyrus and in the pos-

terior lateral gyrus. In the right lateral gyrus, however, a same relation was observed. An facilitatory and inhibitory interactions were, therefore, observed in the ipsilateral somatosensory (rPS) and visual areas (rL, rPL).

By combining the stimulation to the right lateral geniculate body with the binocular stimulation, therefore, the responses in the bilateral posterior sigmoid gyri (lPS, rPS), bilateral lateral gyri (lL, rL) were enhanced, while in the bilateral posterior lateral gyri and left lateral geniculate body inhibitory changes were observed.

In comparing the autocorrelograms of the EEG recordings during the monocular (Fig. 7-3, A) with those during the binocular stimulation (Fig. 7-3, C), it was observed that a more prominent responses were elicited in all regions by binocular stimulation than the responses due to the monocular stimulation.

In the power spectra (Fig. 7-3, D), a higher peak to reveal a facilitatory interaction under the combined stimulation was clearly observed at the stimulating frequency in the both of the posterior sigmoid gyri (lPS, rPS), while the peak at the first high harmonics (16 c/sec) were lower during the combined stimulation to reveal an inhibitory interaction. In the lateral gyri (lL, rL), a reverse evidences were observed. In the posterior lateral gyri (lPL, rPL), all the peaks at the stimulating frequency and the first and the second high harmonic frequencies were lower in the instance of the combined stimulation. In the left lateral geniculate body (lGL), however, enhanced peak during the combined stimulation was observed at the stimulating and the second high harmonic frequency, while slightly lowered peak appeared at the first high harmonic frequency.

c. Interactions between visual and cutaneous afferent inflows. Some observations were performed on the EEG activities elicited by monocular flicker stimulation alone
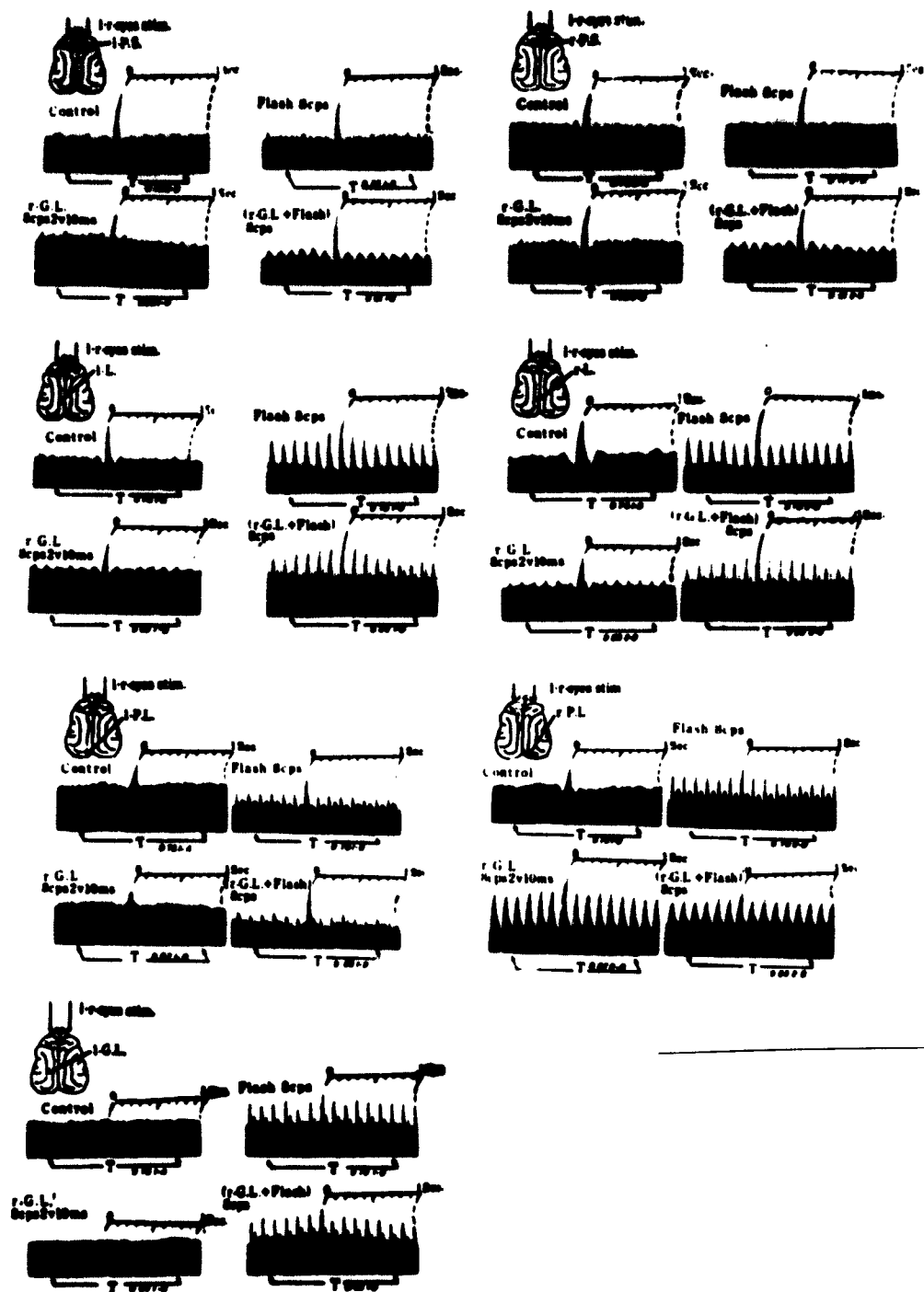
Fig. 7-3C. Autocorrelograms of EEGs during rhythmic binocular and right lateral geniculate stimulation with 8 per sec.

Abbreviations see Fig. 7-3A.
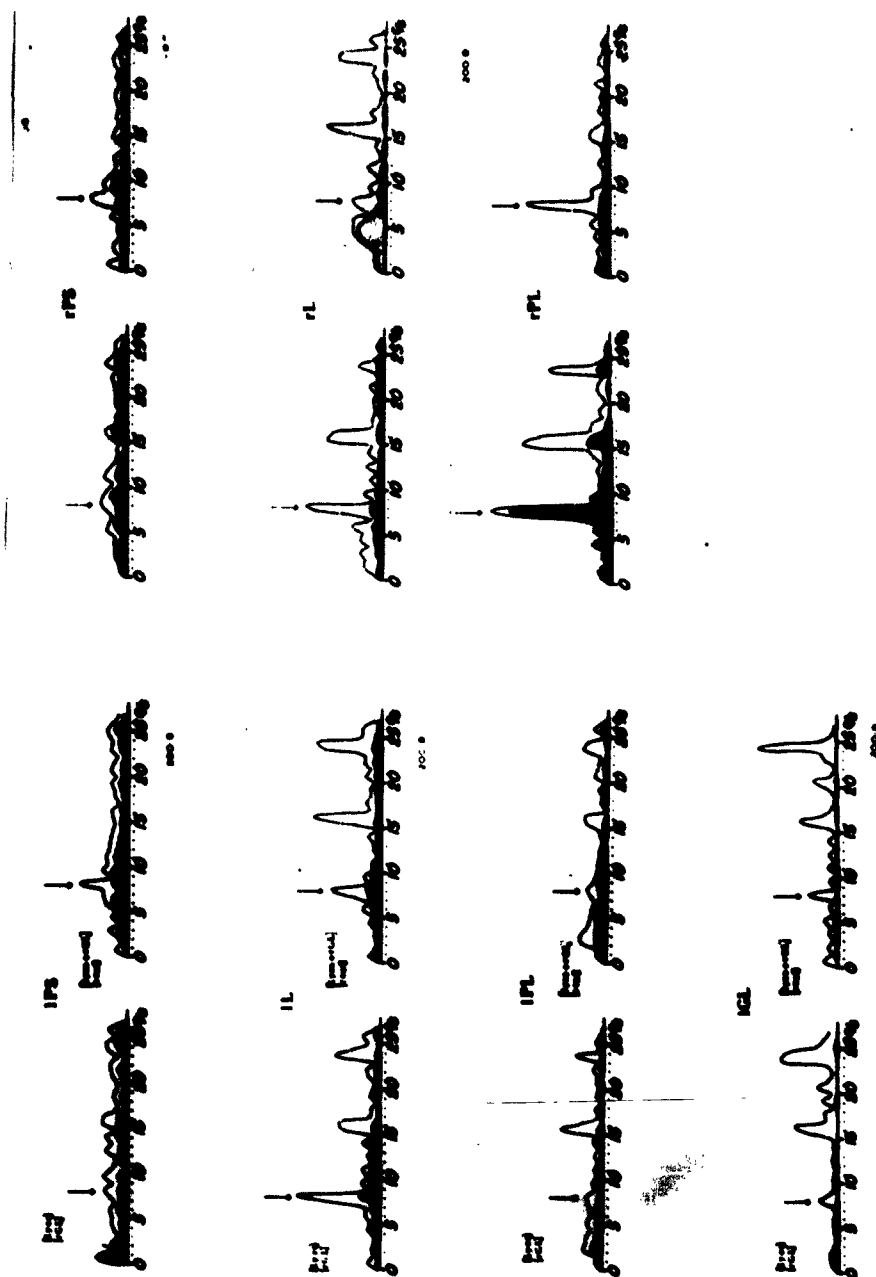
Fig. 7-3D. Frequency spectra of the autocorrelograms in Fig. 7-3C.

Abbreviations see Fig. 7-3B.

and synchronously combined stimulation of this flicker and rhythmic electric shock to the ipsilateral main pad of unanesthetized and immobilized cats. Frequency response behaviors of EEGs in bilateral lateral gyri (l. Lat and r. Lat) posterior sigmoid gyri (l. post. sigmoid.), left nucleus centrum medianum and right lateral geniculate body were surveyed with the frequencies ranging from 3 to 11 per sec in about 2 c/sec steps. It was very often observed as can be seen in Fig. 7-4 that in spite of EEG responses were difficult to evaluate from the EEG tracing themselves, their autocorrelograms revealed some qualitative properties of the average time-patterns of the responses. In addition, the frequency spectra of the autocorrelograms obtained by the instant spectrum analyser verified the frequency-patterns of the average responses not only qualitatively but also quantitatively.

In an unanesthetized and immobilized state an irregular pattern of oscillations was ften observed in the EEG records themselves. In their autocorrelograms, however, no prominent oscillation was visualized, while in their amplitude spectra (power spectra of the EEG records) some low peaks to suggest intrinsic EEG activities were observed in the frequency range of human delta (0.5-3.5 c/sec), theta (4-7.5 c/sec) and alpha (8-13 c/sec) waves (Fig. 7-4 control).

As there are often observed irregular back ground EEG activities in the EEG recordings before the initiation of the experimental stimulation (Fig. 7-5, 6, 7, 8 and 9; A) and during the delivery of the experimental stimulation the EEG responses will be distorted and/or masked by them. Taking the crosscorrelogram of the stimulation and the EEG recording, the response only will be obtained, because irregular back ground oscillations irrelevant to the stimulation will be cancelled (Fig. 7-5, 6, 7, 8 and 9; B).

d. Effects of the stimulation of the midbrain reticular formation.
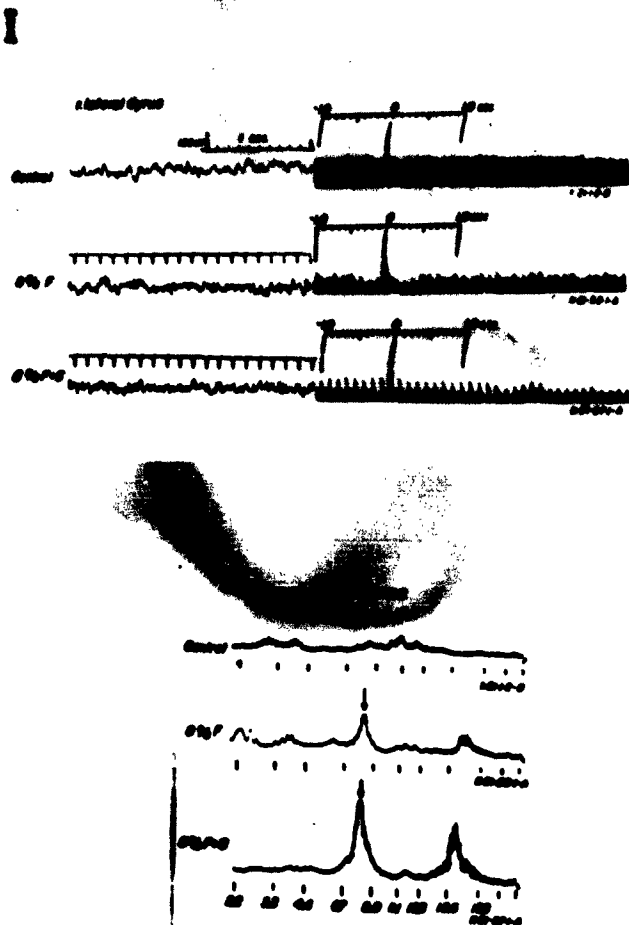
Fig. 7-4. EEG response elicited by rhythmic binocular and cutaneous stimulation with 8 per sec.

I. Left: EEG curves in the right lateral gyrus and the signals
       of the stimulation.
   Right: Autocorrelograms of the corresponding EEG curves on
       the left.
II. Frequency spectra of the corresponding autocorrelograms
     on the left.

From the top to down the recordings during the control without experimental stimulation, binocular flickering stimulation and the combined one of these two are illustrated.

- 45 -
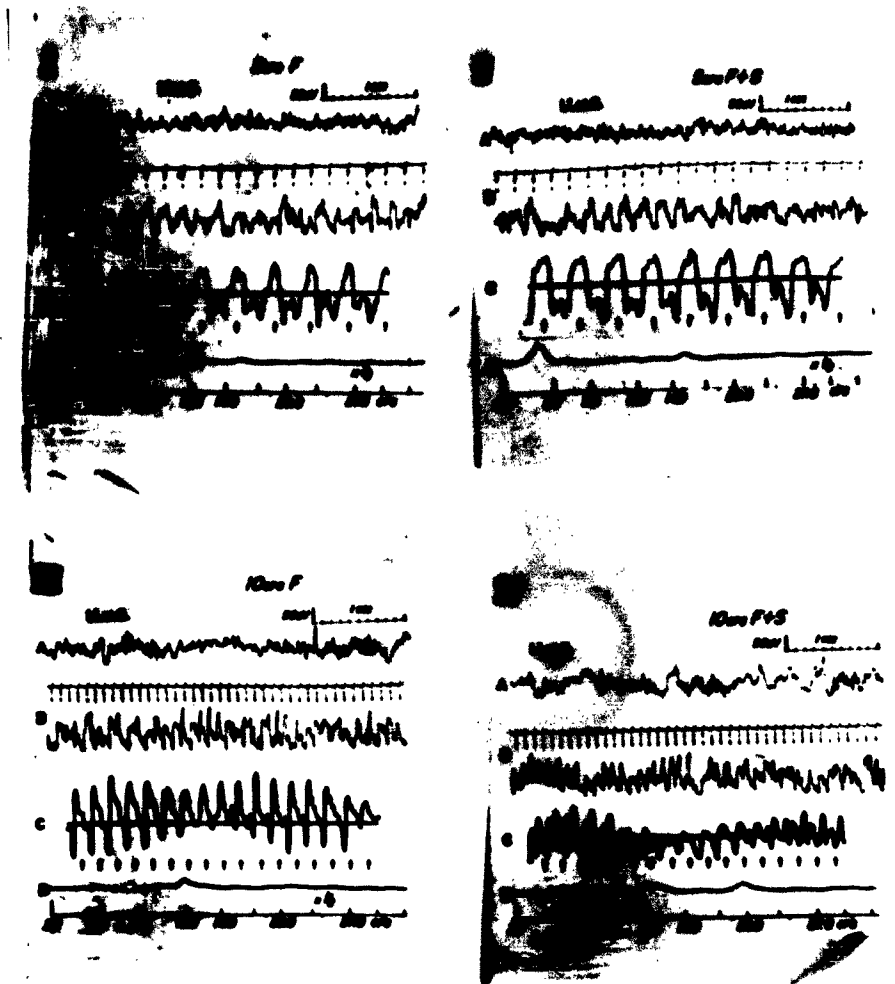
Fig. 7-5. An example of EEG recording showing augmentative and depressive EEG responses by cutaneous stimulation in the left lateral gyrus.

A: EEG recordings in the state of no experimental stimulation.
B: Simultaneous recordings of signal of the stimulation and EEG. C: Crosscorrelograms of the stimulation and the EEG. Arrows pointing upward show signals of the stimulation. D: frequency spectra of the crosscorrelograms.
I and II: Photic flicker stimulation only (F) and the combination of the photic and cutaneous stimulations (F + S). Stimulating frequency was 5 c/sec.
III and IV: Quite the same as I and II respectively. Stimulating frequency was 10 c/sec.

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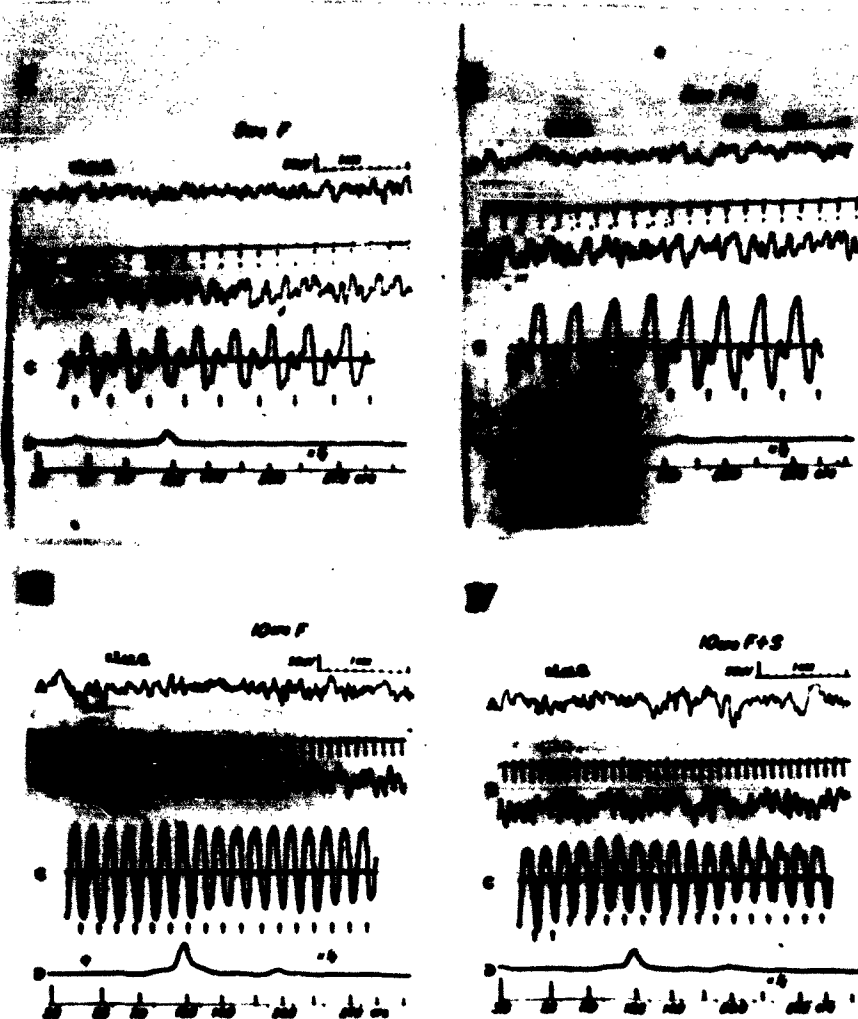
Fig. 7-6. An example of EEG curves and EEG responses in the **right** lateral gyrus of a cat.

Abbreviation see Fig. 7-5.
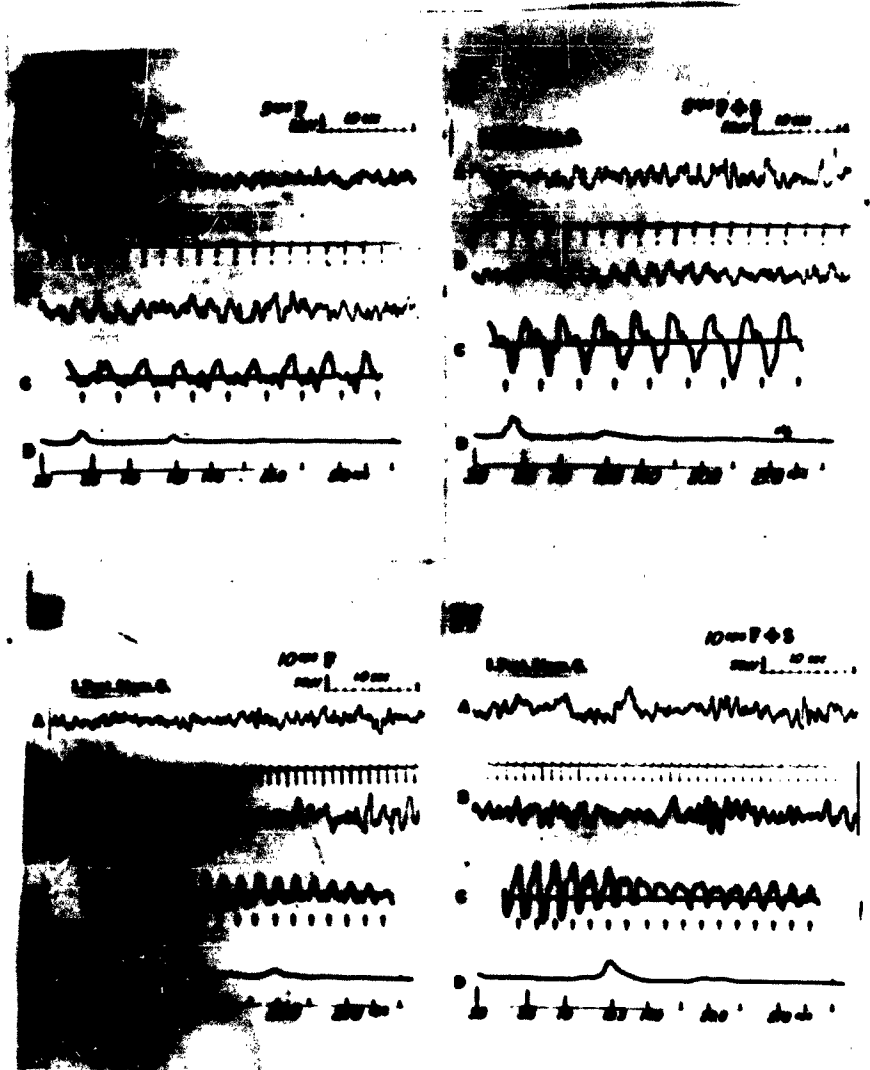
Fig. 7-7. An example of EEG curves and EEG responses in the left posterior sigmoid gyrus of a cat.

Abbreviations see Fig. 7-5.
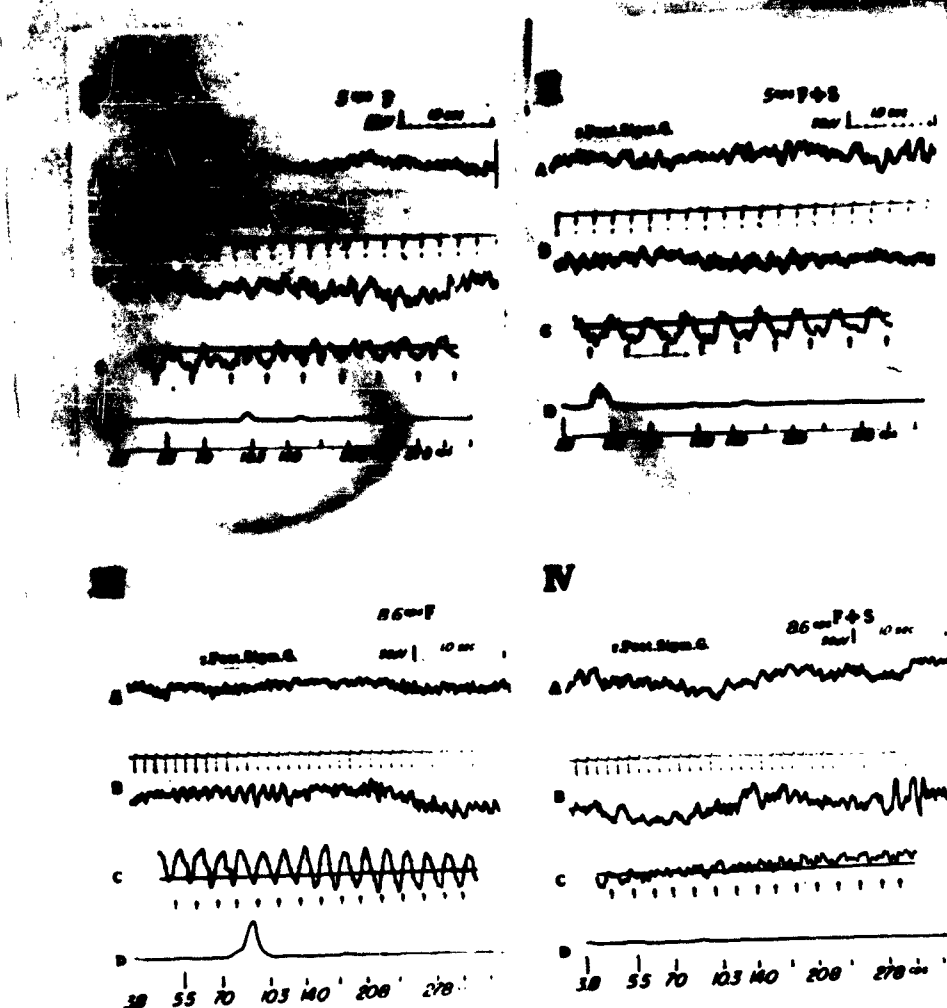
Fig, 7-8. An example of EEG curves and EEG responses in the right posterior sigmoid gyrus of a cat.

Abbreviations see Fig. 7-5.
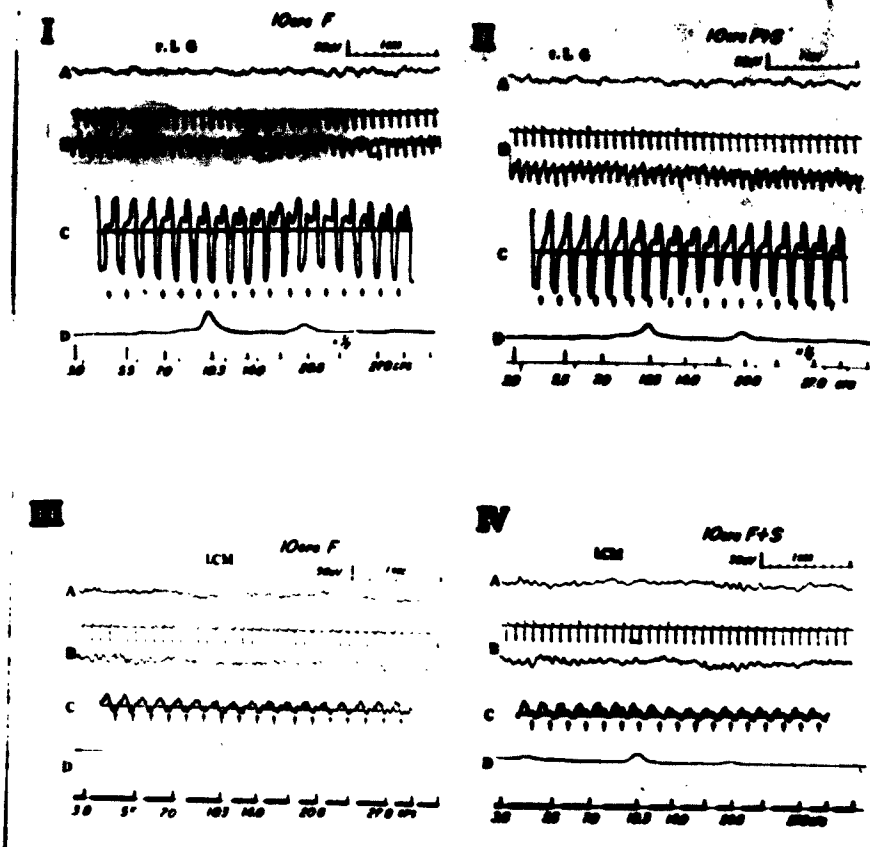
Fig. 7-9. An example of EEG curves and EEG responses in the right lateral geniculate body (I, II) and left nucleus centrum medianum (III, IV) of a cat.

Abbreviation see Fig. 7-5.
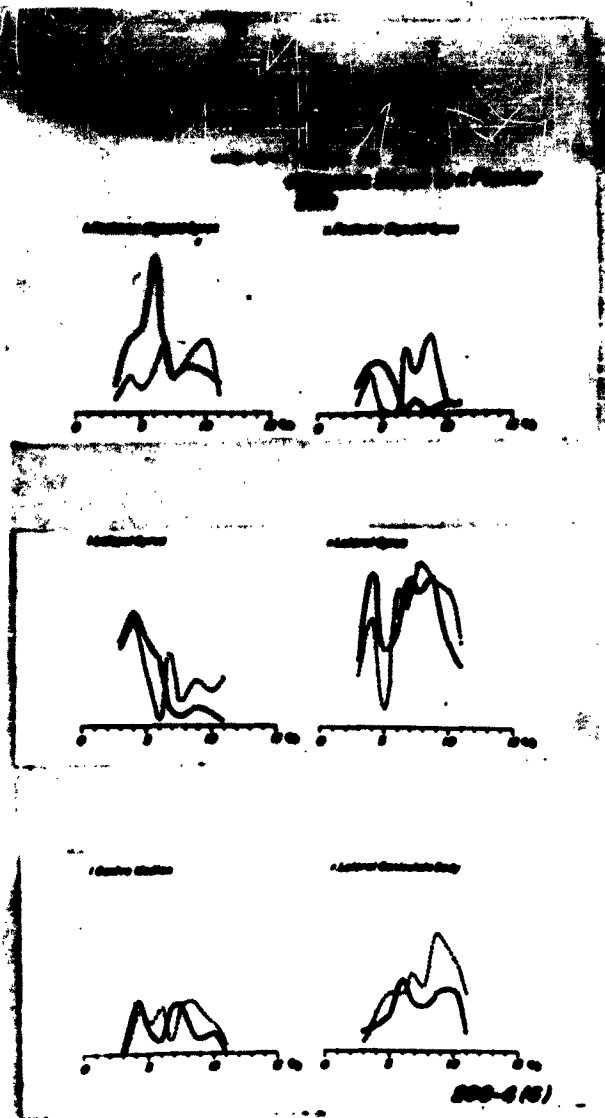
Fig. 7-10. Frequency response elicited by binocular flickering
flash stimulation and rhythmic electric shock to right main pad
of a cat.

Full line: Frequency response by binocular stimulation only.
Dotted line: Frequency response by the combined stimulation
            of the binocular and cutaneous stimulation.
Upper left and right: Left and right posterior sigmoid gyri.
Middle left and right: Left and right lateral gyri.
Lower left and right: Left nucleus centrum medianum and right
                    lateral geniculate body.

(1) **High frequency stimulation**. It has been well recognized that a high frequency electric shock stimulation to the brain stem reticular formation leads to a diminution or abolishment of the basic EEG potentials and in place of them low voltage fast oscillations are induced.

As can be seen in Fig. 7-11, high frequency stimulation (200 /sec, 1.5 Volt strength, 0.1 msec duration) to the unilateral midbrain reticular formation, by which low voltage fast activities were observed in the bilateral lateral gyri, yielded an inhibition of the photically induced EEG responses of low frequency in the ipsilateral lateral gyrus, whereas an augmentation of the EEG responses in the contralateral lateral gyrus.

In Fig. 7-12,E, some changes in the autocorrelograms of EEG records caused by high frequency unilateral reticular stimulation are illustrated. In the left and right posterior lateral gyri (lL and rL) and right lateral geniculate body (rGL), not only enhancement of the slow oscillation in the autocorrelograms before delivery of the stimulation in some instances (Fig. 7-12,E, lL-B, rL-B, rGL-A), but also diminution of the oscillation was also observed by the reticular stimulation (lL-A, rL-A, rGL-B). In the latter, low and fast oscillations were superimposed in the diminished slow wave forms. In the amplitude spectra of the autocorrelograms these evidences were also indicated in the change of peak heights. In the left lateral gyrus (lL), the peaks located at about 1.5, 4 and 7.5 c/sec in the spectrum of the autocorrelogram 'A-left' without the reticular stimulation (Fig. 7-12,E, right lL,a) were lowered in their heights in the spectra of the autocorrelogram 'A-left' during delivery of the reticular stimulation (Fig. 7-12,E, right lL, A), while a peak at the frequency of 25 c/sec was enhanced in the latter spectrum, by which the above noted superimposition of the low and fast oscillations were verified. In the spectra (Fig. 7-12,E, right, b and B) of the autocorrelograms B in

- 52 -
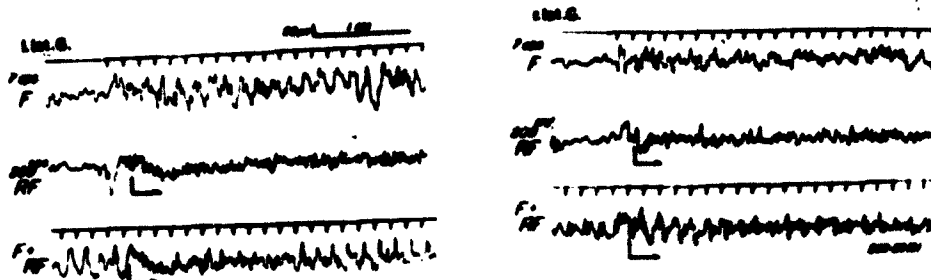
Fig. 7-11. An inhibitory and augmentative effect of high
frequency stimulation to the midbrain reticular formation
upon the EEG response.

EEG curves on the left and right are led respectively
from the left (l.Lat.G) and right lateral gyri (r.lat.G).
F: Photic flicker monocular stimulation of 7 per sec to
   right eye.
RF: Rhythmic electric shock 200 per sec 1.5 volt, 0.1 msec
    to the left midbrain reticular formation.
F + RF: The combined stimulation of the above two.

Arrows in the middle and lowest curve indicate the initi-
ation of the high frequency reticular stimulation.
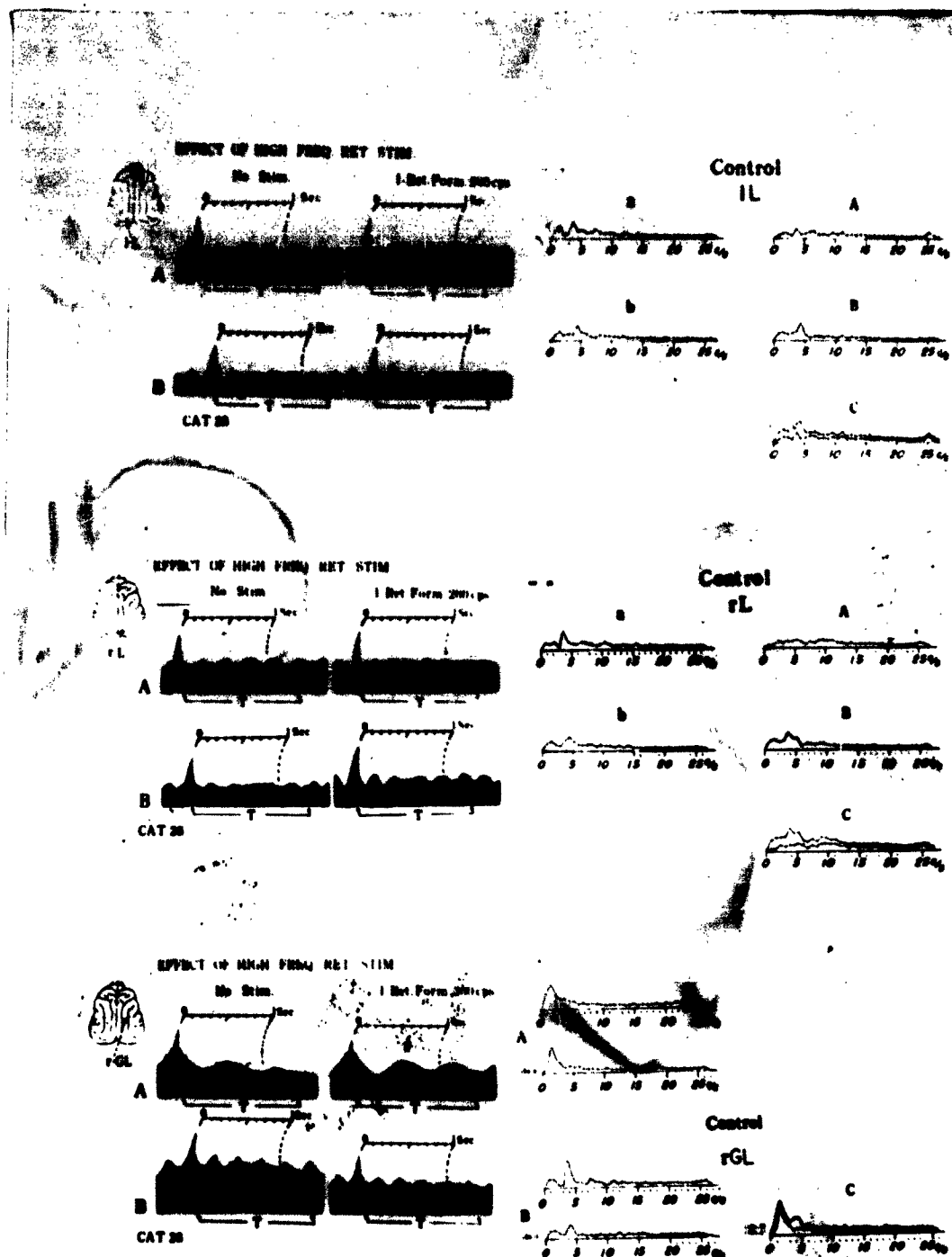
Fig. 7-12E. Effect of high frequency reticular stimulation.
(See next page)

Fig. 7-12E. Effect of high frequency reticular stimulation.

Left. Autocorrelograms of EEGs in the bilateral posterior
portion of the lateral gyri (l-L and r-L) (top and inter-
mediate pairs) and right lateral geniculate body (r-GL) (the
lowest pair).   In each region, uppermost two autocorrelo-
grams (A) were computed from EEGs before delivery of many
rhythmic stimulations for obtaining the frequency response
behavior and lower two autocorrelograms (B) were derived from
EEGs after repeating many rhythmic stimulations.
Left autocorrelograms in A and B: The controls without re-
ticular stimulation.
Right autocorrelograms in A and B: Electric shock of 200 /sec
(2 V, 0.1 ms.), to the left midbrain reticular formation.

Abbreviations in bilateral lateral gyri (lL and rL).
Right: Frequency spectra derived from the autocorrelograms
on the left.
a and b: Control without the reticular stimulation.
A and B: High frequency stimulation to the left midbrain
reticular formation.
a, b, A and B are correspondingly obtained respectively from
autocorrelograms illustrated in A-left, B-left, A-right and
B-right.
C: Summation of the spectrum A and B.

  Abbreviations in the right lateral geniculate body (-GL).
Upper spectra in A and B were computed from the autocorrelo-
grams on A-left and B-left respectively, i.e. the control.
  Lower spectra in A and B were obtained from the auto-
correlograms on A-right and B-right respectively, i.e. high
frequency stimulation to the left midbrain reticular formation.
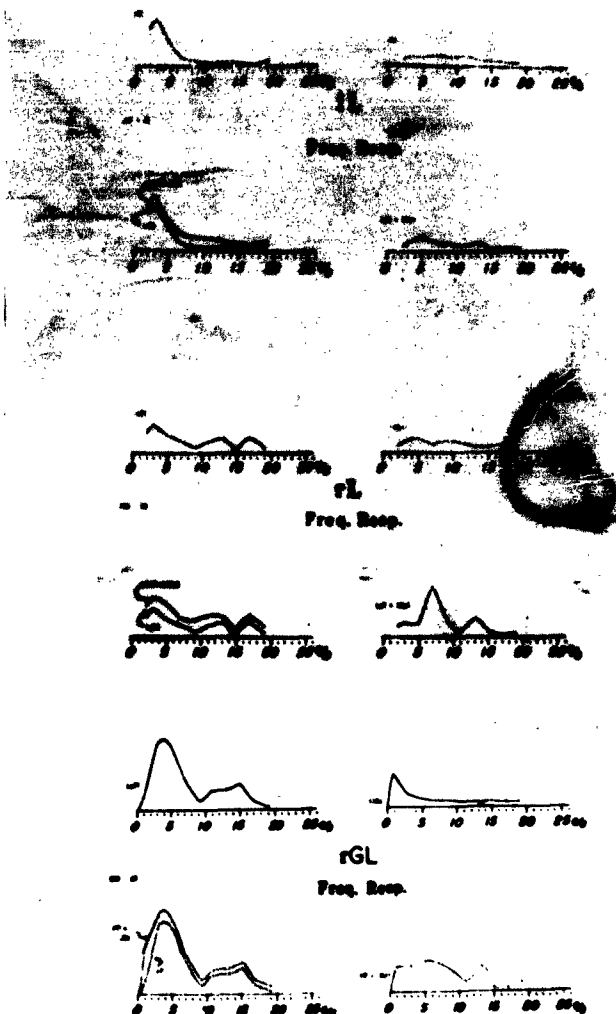
Fig. 7-12F. Influence of high frequency reticular stimulation upon the frequency response of EEG.

1L and rL: posterior portion of the left and right lateral
gyri respectively.

rGL: right lateral geniculate body.

In each regions, four curves are illustrated. The upper left one (rF) is the frequency response elicited by right monocular photic flicker stimulation. The upper right one (1Re) is derived from the frequency spectrum C in Fig. 7-12E. The ordinates were taken as half those in C, i.e. the average height of the two spectra. The lower left one (rF) + (1Re) is the summation of the above two curves, (rF) and (1Re). The lower right one, (rF + 1Re), is the frequency response elicited by the combined stimulation.

the left lateral gyrus (1L) reverse changes in the peak
heights in the frequency range of lower than 5 c/s were ob-
served by the reticular stimulation, while no peak at about
25 c/sec was enhanced. Quite a similar results were observed
in the right lateral gyrus (Fig. 7-12,E, rL).

In the spectrum of the right lateral geniculate body, an
enhancement of the peak height of about 1.5 c/sec was observed
in A (Fig. 7-12,E, r-GL A). Corresponding to the fact that
a decrement of the oscillation in the autocorrelogram B of
lateral geniculate body was observed by the reticular stimu-
lation, not only peaks located at about 1.5 and 4 c/sec were
lowered in its spectrum (r-GL, B) by the reticular stimulation,
but peaks at high frequency range were also decreased in their
heights. In Fig. 7-12,F, the frequency response patterns
evoked by right monocular photic flickering stimulation only
and by the combination of this stimulation and high frequency
stimulation (200 /sec, 2 volts, 0.1 ms) to the left midbrain
reticular formation in the bilateral posterior portions of
the lateral gyri (1L and rL) and right lateral geniculate body
are illustrated. On the frequency response due to the com-
bined stimulation in the right posterior portion of lateral
gyrus (rL) a higher peak was observed than the summated one
of the frequency response elicited by the photic stimulation
only and the frequency spectrum during the high frequency
reticular stimulation.

In the left posterior portion of lateral gyrus (1L) and
right lateral geniculate body (r-GL), however, the peaks in
the former were lower than those in the latter. Consequently,
an augmentative effect of the unilateral reticular stimulation
was observed in the contralateral posterior portions of later-
al gyrus, while an inhibitory effect was observed in the ipsi-
lateral posterior portion of lateral gyrus and contralateral
lateral geniculate body.

More experimental data would be necessary to make clear
the influence of high frequency reticular stimulation upon

the EEG activities in the cerebral cortex. In the next FINAL REPORT more precise experimental data and their physiological significances will be reported.

(2) <u>Low frequency stimulation</u>. By a low frequency stimulation to the unilateral midbrain reticular for-(Fig. 7-13,RF)^{mation}, EEG responses of the stimulating frequency were observed in the bilateral lateral gyri, wherein the induced response were more remarkable in the ipsilateral gyrus than that in the contra-lateral gyrus. Even when the double or tripple EEG responses were driven by one flash stimulus in the low frequency photic flickering series, the response induced by the low frequency stimulation to the midbrain reticular stimulation was sinusoidal in its wave form (Fig. 7-13).

By synchronous combination of the reticular and flickering stimulations, the second and third responses in the above double and tripple response were augmented respectively. Although the response amplitude elicited by the combined stimulation is higher than each response due to photic or reticular stimu-lation only, the former was lower than the summation of the latter two in the left lateral gyrus except in the instance of 1 c/sec stimulation (Fig. 7-14, l. lat. G, Fig. 7-15, 1L). In the right lateral gyrus (Fig. 7-15, rL), however the former response was higher when the stimulating frequency was lower than 7 c/sec and higher than 15 c/sec. .

e. <u>Reticular influences upon the myotonographic (MT) and EEG activities</u>. High frequency stimulation to the midbrain reticular formation caused inhibition and augmentation of the myotonograms. As can be seen in Fig. 7-16A, very slight en-hancement of myotonograms (r-MT and l-MT) led from bilateral lateral thighs was observed by the stimulation of strength of 1 volt and 0.1 ms duration with the frequency of 100 /sec to the left midbrain reticular formation, wherein EEGs in the ipsilateral posterior sigmoid (1-PS) and lateral gyri (1-L)
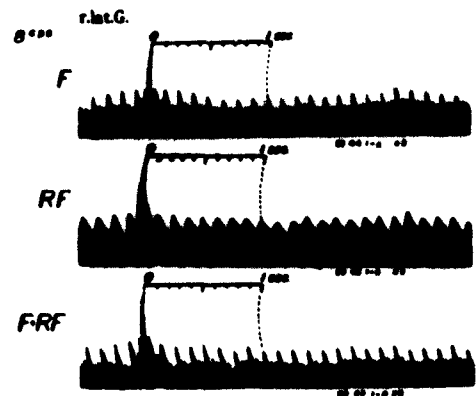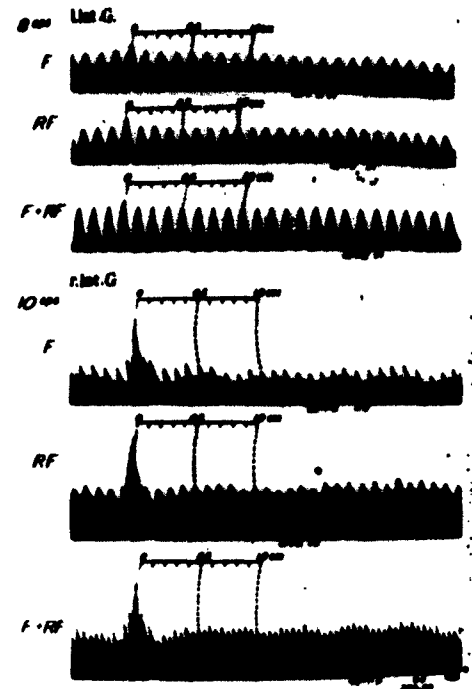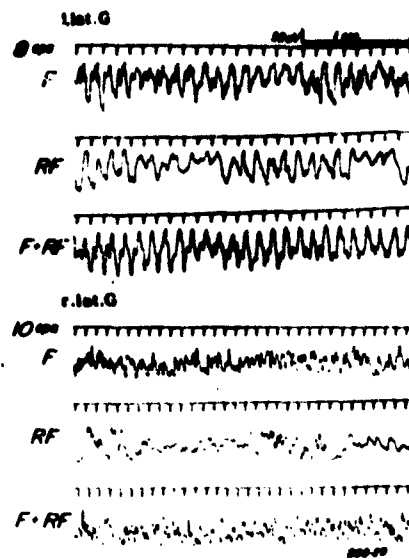
Fig. 7-13. EEG response elicited by low frequency reticular stimulation in the lateral gyri.

F: right monocular photic flickering stimulation.
RF: rhythmic electric shock to the left unilateral midbrain reticular formation.
F + RF: synchronously combined stimulation of the above two.

l. lat.G

8 cps

RF

F

x l

F + RF

6.7   8.9

6.7   8.9   cps

r. lat.G

10 cps

RF

F

x 3

F + RF

8.9   11.1

8.9   11.1   cps
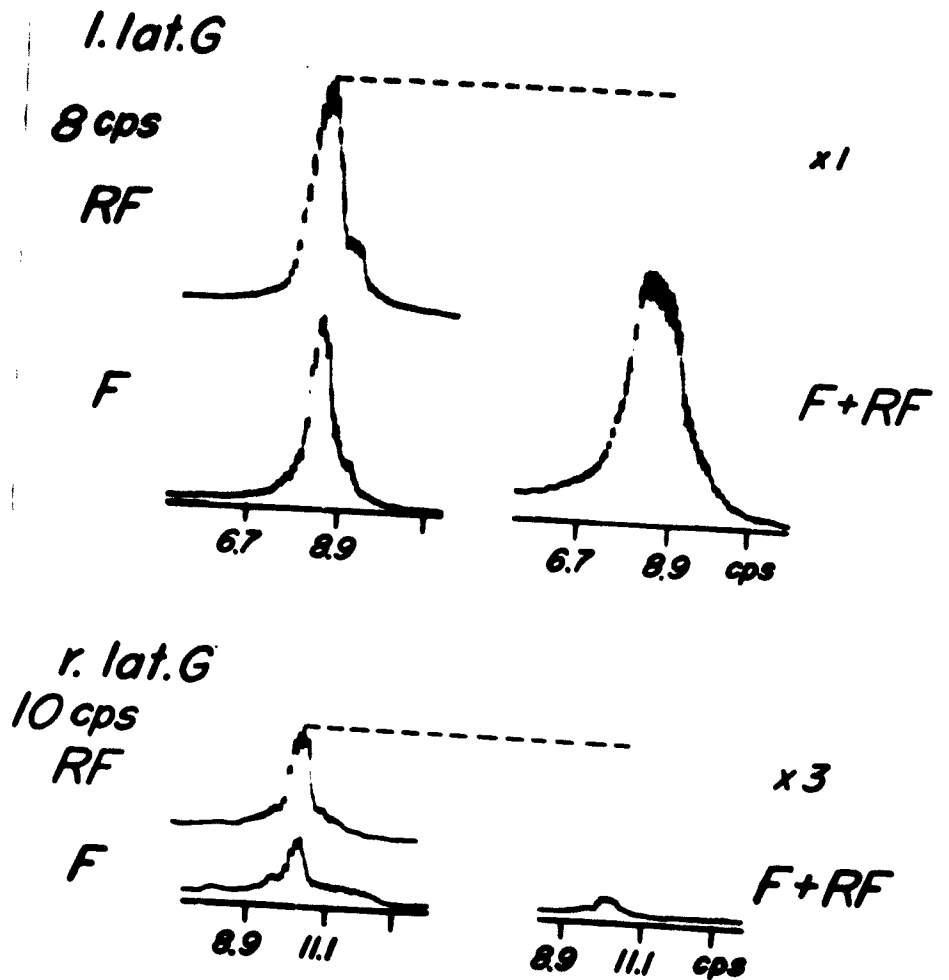
200-29

Fig. 7-14. Frequency spectra of the autocorrelograms in Fig. 7-13.

Abbreviations are the same as those in Fig. 7-13.
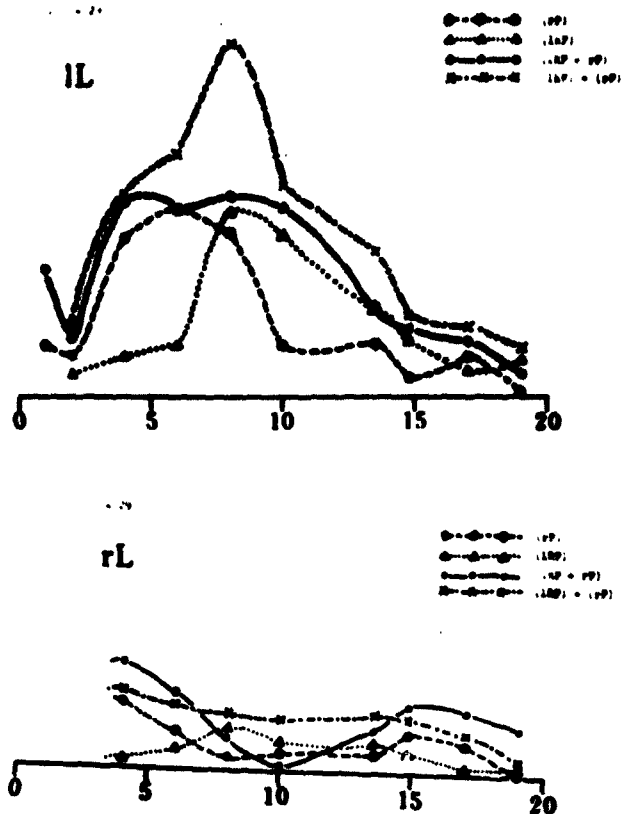
Fig. 7-15. Influences of stimulation to the midbrain re-
ticular formation upon the frequency response in the cere-
bral cortex.

(rF): Frequency response elicited by right monocular flash
      stimulation.
(1RF): Frequency response evoked by the rhythmic electric
      shock stimulation to the midbrain reticular formation.
(1RF + rF): Frequency response induced by the synchronous
           combination of the above two stimulations.
(1RF) + (rF): Summation of the two frequency responses (rF)
           and (1RF).
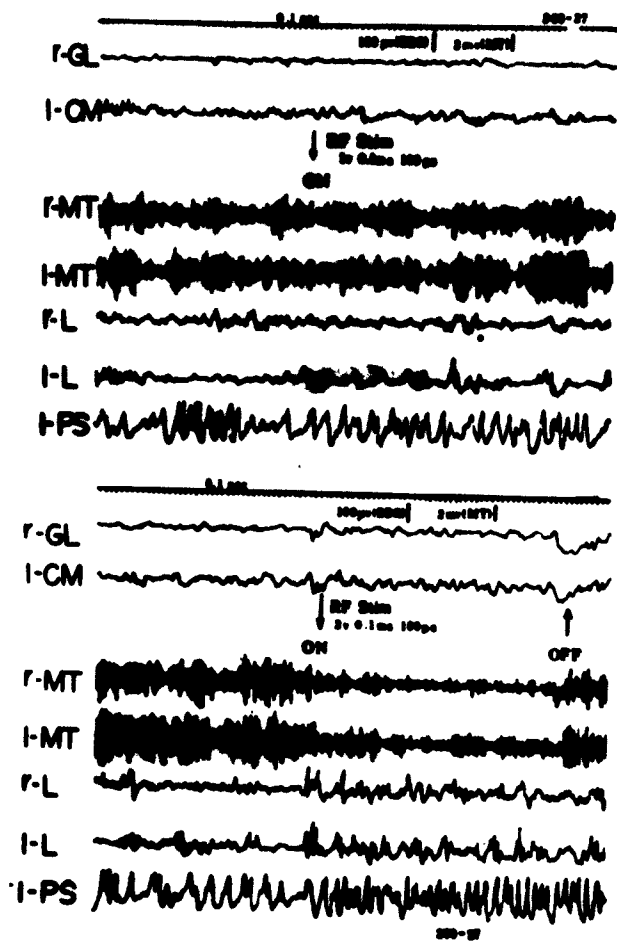
Fig. 7-16A. Effect of high frequency stimulation to the
midbrain reticular formation upon the myotonograms (MTs) and
EEGs. (See next page)

Fig. 7-16A. Effect of high frequency stimulation to the midbrain reticular formation upon the myotonograms (MTs) and EEGs.

MTs were led from the surface of bilateral thigh
r and l: right and left.
GL: lateral geniculate body.
CM: nucleus centrum medianum (centre médian).
L: lateral gyrus (visual area)
PS posterior sigmoid gyrus (somatosensory area).
Arrow pointing down (ON): Initiation of high frequency rhythmic electric shocks (100 /sec 0.1 msec) to the left midbrain reticular formation.
Arrow pointing upward (OFF): Cessation of the reticular stimulation.
Upper curves: 1 volt stimulation.
Lower curves: 2 volts stimulation.
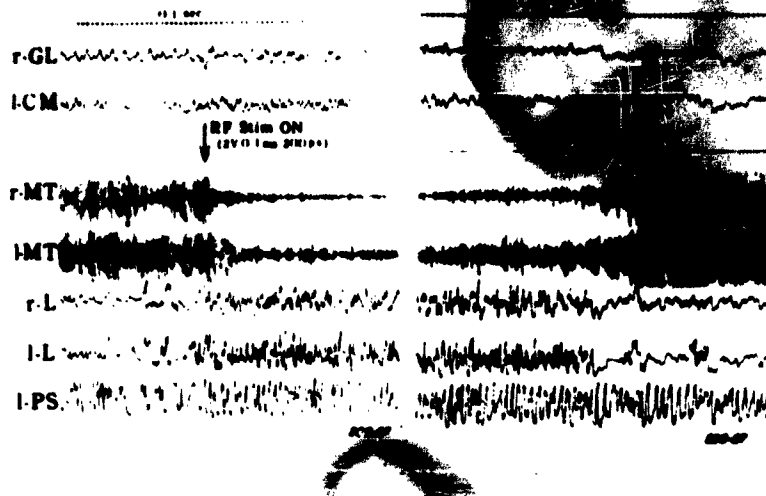
Fig. 7-16B. Inhibitory effect of the high frequency reticular stimulation upon the MTs.

Abbreviations see Fig. 7-16A. Stimulation was 200 /sec, 2 volts, 0.1 msec.

were also induced slow fluctuations. When the strength of
high frequency unilateral reticular stimulation was made
stronger to 2 volts, however, a reverse change in the bilateral
myotonograms was obviously observed and EEGs were augmented
not only in the ipsilateral posterior sigmoid (1-PS) and lateral
gyri (1-L), but also enhanced in the contralateral lateral
gyrus (r-L). In addition, EEG oscillations in the ipsilateral
nucleus centrum medianum (1-CM) and in the contralateral later-
al geniculate body (r-GL) were also augmented. As illustrated
in Fig. 7-16B, increased the stimulating frequency to 200 c/sec,
the inhibitory effect upon the bilateral myotonograms (r-MT,
1-MT) became more prominent and a rebound phenomenon was ob-
served after cessation of the stimulation. The augmentative
influences upon the EEGs in the ipsilateral posterior sigmoid
gyrus (1-PS), and nucleus centrum medianum (1-CM), bilateral
lateral gyri (1-L, r-L) were also grown up. In addition the
potentials seen before the initiation of the stimulation in
the contralateral lateral geniculate body (r-GL) were observed
in an opposite direction during the stimulation.

The augmentation of slow EEG potentials due to high fre-
quency reticular stimulation would be accounted for lowered
activity in the cerebral cortex and/or caused by the nembutal
anesthesia in the cortico-thalamic and thalamo-cortical re-
verberating circuits. In an immobilized cat by administration
of flaxedil, as can be seen in Fig. 7-17, high frequency stimu-
lation to the left midbrain reticular formation lead to an en-
hancement of bilateral myotonograms accompanying low voltage
fast EEGs in the bilateral lateral and posterior sigmoid gyri,
while slow activity of about 3 c/sec was observed in the right
lateral geniculate and left nucleus centrum medianum.

From the above evidences augmentative and inhibitory
influences of the midbrain reticular formation upon the myo-
tonic activities would be verified. In the following experi-
ments and data processings in the extended contract these
central influences upon the frequency response of myotonograms
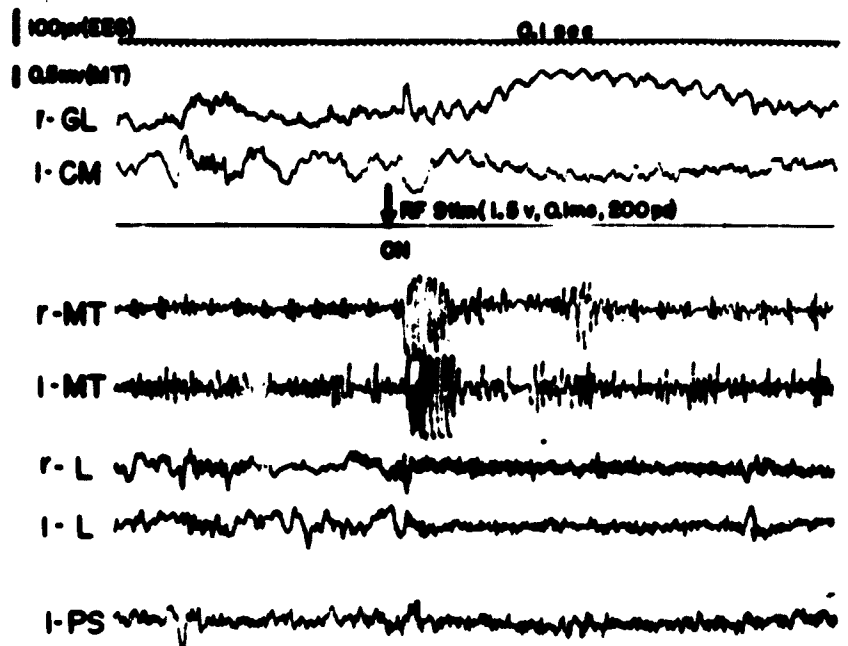
Fig. 7-17. Augmentative effect of high frequency reticular stimulation upon MTs.

Abbreviations see Fig. 17-16.

will be more precisely analysed.

    1. Influences of the thalamic nonspecific nucleus (nucleus centrum medianum) upon the EEG activities. It was revealed by the method of evoked potential (recruiting response) that nonspecific thalamic nuclei belong to the diffuse projection system and they send afferent inflows to various regions of the cerebral cortex especially to association areas. Little evidences in terms of EEG activities were, however, hitherto obtained.

    EEG response in the association area, for instances in the suprasylvian gyrus (SS), were yieded also by photic flickering visual stimulation, as illustrated in Fig. 7-18.1, when the crosscorrelograms of the rhythmic stimulation and EEG were obtained by our method or by the pulse signal correlator. In many instances the stimulation to the left nucleus centrum medianum (1CM) elicited sinoidal wave like EEG response in the posterior sigmoid (Fig. 7-18.1A and B), suprasylvian (C and D) and posterior suprasylvian gyri (E and F), on which, however, small fast responses were superimposed to distort the wave form, while photic stimulation evoked double or tripple responses in many instances (Fig. 17-18, 1). In some instances, the EEG responses were depressed by combining the two stimulations, while they were augmented by the same stimulation.

    Consequently, influences of the nucleus centrum medianum stimulation upon the EEG responses to photic flicker stimulation were observed and frequency response behavior respectively under photic flicker stimulation, electric shocks to the nucleus centrum medianum and the synchronously combined stimulations were surveyed with the frequencies ranging from 1 to about 20 per second in about 1 per sec steps in lower frequencies than 15 c/sec and in about 3-5 c/sec steps in higher frequencies than 15 c/sec.

    In Fig. 7-19, a case of the frequency responses in the bilateral posterior sigmoid (1PS and rPS), bilateral lateral
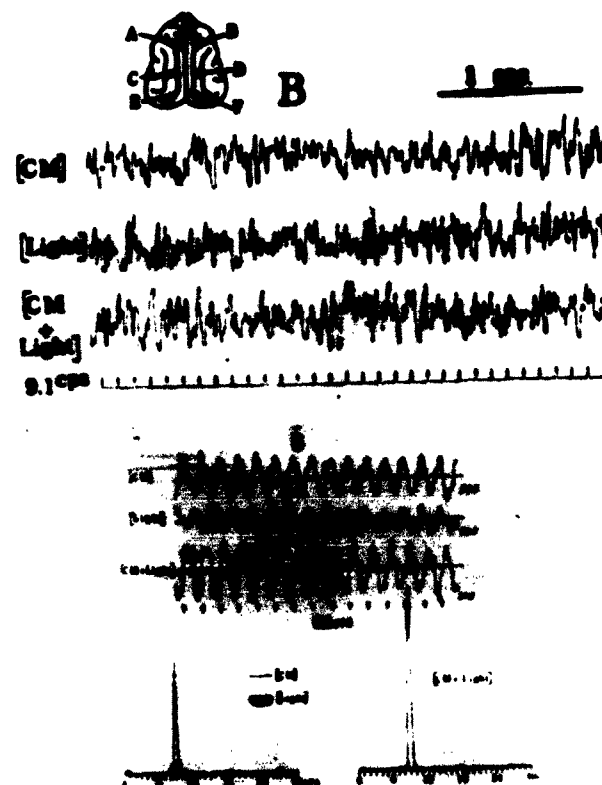
Fig.7-18. EEG responses induced by low frequency stimulation to the nucleus centrum medianum.

A, B: left and right anterior portions of the lateral gyri respectively

C, D: left and right suprasylvian gyri (association areas) respectively.

E, F: left and right posterior portions of suprasylvian gyri.

(CM): rhythmic electric shock stimulation to the left nucleus centrum medianum.

(Light): binocular photic flickering stimulation.

(CM + Light): the synchronously combined stimulation of the above two.
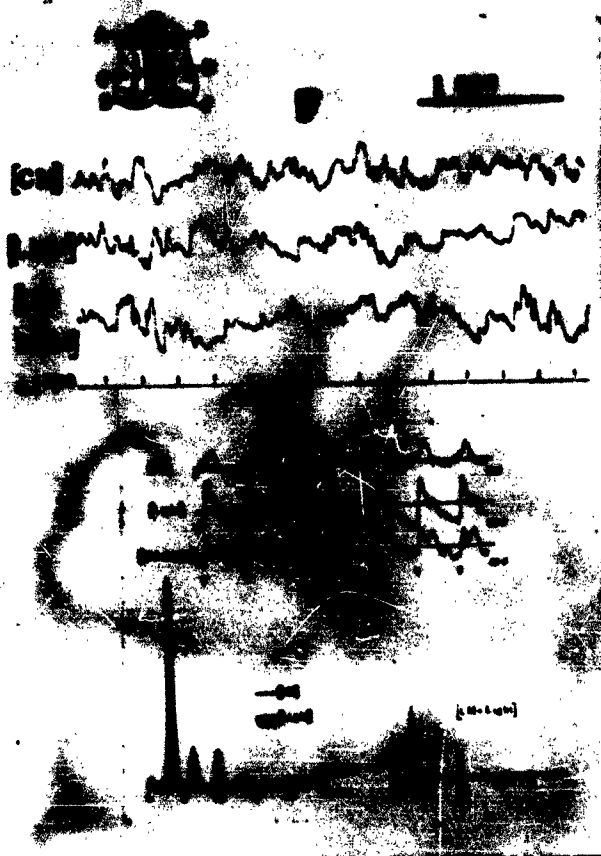
Fig. 7-18,1F. EEG responses induced by low frequency stimulation to the nucleus centrum medianum.

A, B: left and right anterior portions of the lateral gyri
    respectively.
C, D: left and right suprasylvian gyri (association areas)
    respectively.
E, F: left and right posterior portions of suprasylvian gyri.
(CM): rhythmic electric shock stimulation to the left nucleus
    centrum medianum.
(Light): binocular photic flickering stimulation.
(CM + Light): the synchronously combined stimulation of the
        above two.
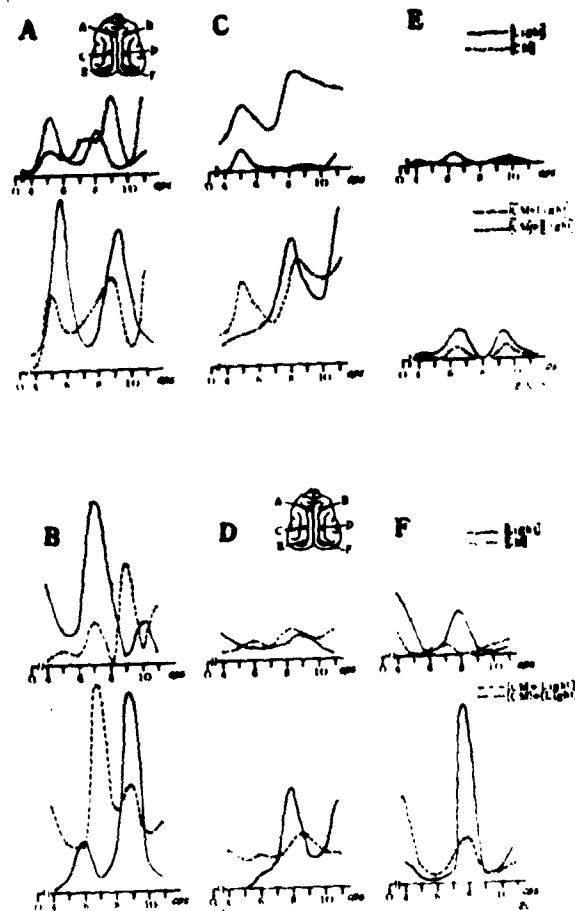
Fig. 7-18,2. Frequency response behaviors in the associ-
ation areas elicited by binocular photic flash stimulation
and/or the stimulation to the left centrum medianum.

Abbreviations see Fig. 7-18, 1B and F.
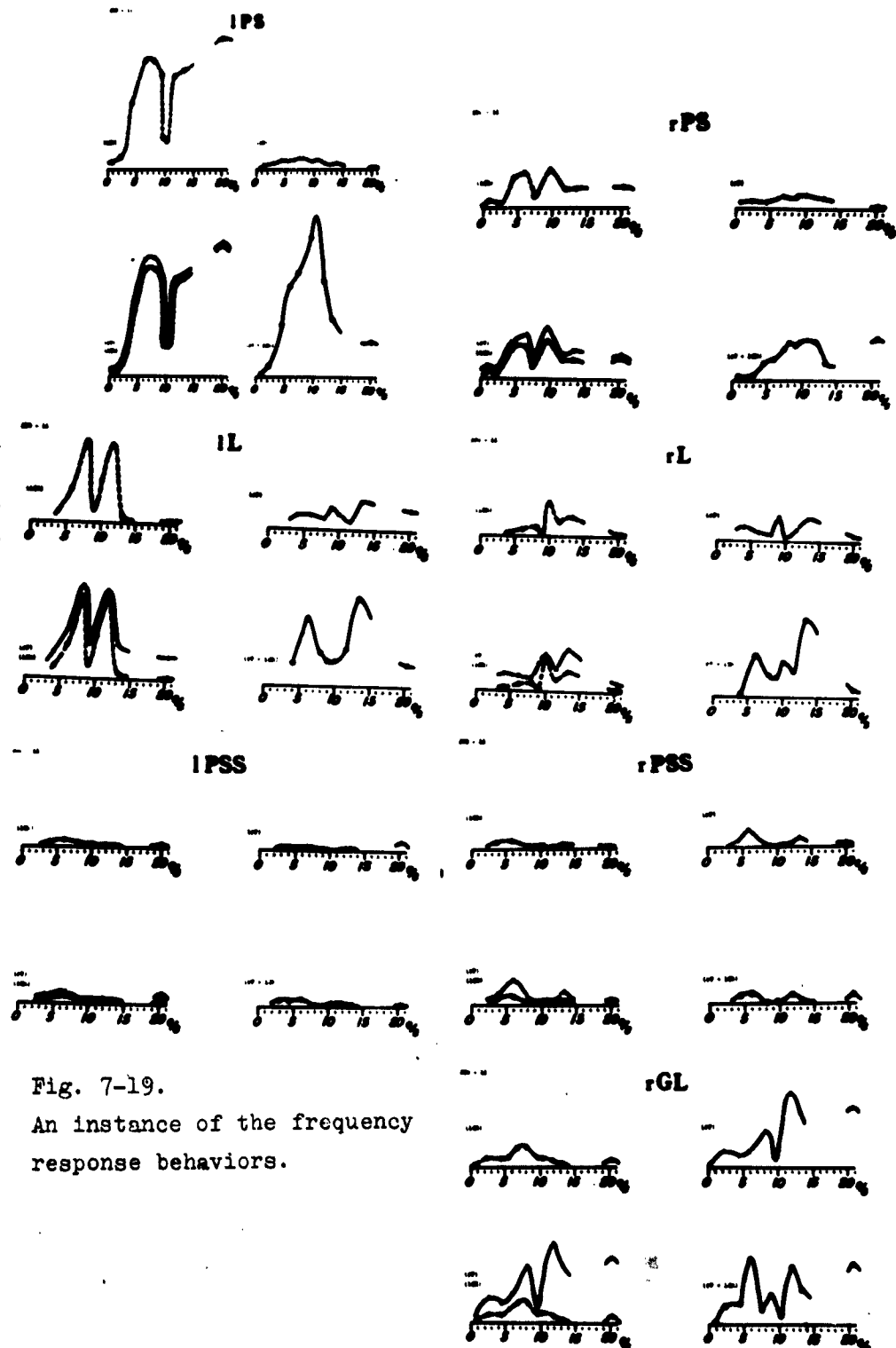
Fig. 7-19.
An instance of the frequency
response behaviors.

(1L and rL), bilateral posterior suprasyrvian (1PSS and rPSS) gyri and right lateral geniculate body elicited by photic flickering stimulation to right eye, those by the rhythmic electric shock to left nucleus centrum medianum and those by the combined one of the two stimulations are illustrated.

Other inkwritten and magnetically recorded data on these frequency responses were obtained. Data processings for verifying the frequency response behaviors, however, are not yet completed, but are in progress, because it takes time for carrying these data processing.

8. POSITIVE OR NEGATIVE CORROBORATION

As basic EEGs of men and animals are irregular potential oscillations with the frequencies in the range of from 8 to 12 c/sec, EEG responses due to various stimulations with a frequency in the above frequency range were observed before obtaining the frequency responses in the cerebral somato-sensory and visual cortex.

As various afferent inflows converge in the cerebral cortex, there are various interactions between them to cause inhibitory and/or augmentative EEG activities. Even in the EEG responses induced by photic flicker stimulation only, there are interactions between right and left monocular stimulations, between photic and geniculate stimulation, between photic and reticular stimulations etc. Not only interactions between two afferent inflows to the cerebral cortex, local differences in the lateral gyrus (visual area) should be observed, because it is long area as already pointed out.

Little knowledge about the interactions in EEG activities and their physiological significance are obtained hitherto. Some important contributions would be found in our results noted in the Implications of conclusions.

Though we could perform some research experiments on the frequency response behavior related to the 'Special Research Goal' noted in the Negociated Contract, Article 1,a.(1),

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and innumerable inkwritten and magnetically recorded data
are in our hand.   The results of data processing of them,
however, are not yet piled up enough, because it takes much
time for data processing.   We would like to sum up, there-
fore, in the next Final Report.

From the same point of view of the EEG generator ac-
tivity, myotonogram activity was defined (THE FIRST QUARTERLY
REPORT, Paragraph 2. Fundamental Point of View of the Re-
search), by which the central control mechanism in the neuro-
mascular system would be able to investigate.   The results
of the data processing and further experiments will be reported
in the later report.

9.   CONTRIBUTIONS TO THEORY

From various stand points, physiological significance
of the electroencephalogram (EEG) has been investigated
since Caton (1875) found the cerebral potential irrelevant
to the experimental stimulation of animal, especially since
Berger (1929) succeeded in recording the EEGs from the surface
of human scalp.   Few results have been revealed, however,
compared with the innumerable number of papers reported
hitherto.

On the generating mechanism of the EEG, it will be
generally recognized that a complex summation of the slow
potentials (Tasaki et al. 1954; Jasper 1961; Hild and Tasaki
1962) of excitable membrane originated in the apical dendrites,
neuron somas and/or glia cells in the cortex, like dendritic
potentials, post-synaptic potentials, etc. will be picked up
by the leading (gross) electrode(s) to trace EEGs.

Few results were obtained, however, in what mechanism
the above slow potentials will be summated to form the EEG.

As already noted in the FIRST QUARTERLY PROGRESS REPORT,
Paragraph 2. Foundamental View Point of the Research, Sato

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(1961, 1962a, 1962b, 1963a,b) and Sato, Ozaki et al. (1961a)
made a progressing step in the orginating mechanism of the
EEG, in which EEG potential at an arbitrary time point will
be the algebraic summation of after potentials of the slow
potentials of the brain neighbouring the leading electrode(s)
(EEG generator) evoked by afferent nervous impulses delivered
in the past of this time point (Sato 1962a,b).

Here, the time-pattern of the EEG potential will be
expressed by an integral equation of the time-patterns of
the afferent stimulation and the slow potential of the EEG
generator elicited by a single threshold impulse stimulus
(the "threshold-impulse-response"). And by applying the
Fourier transform to this integral equation, the following
important and fundamental relationship:

(9.1) $X(f) \cdot G(f) = Y(f)$

was obtained, where $X(f)$, $G(f)$ and $Y(f)$ are respectively
the power spectra of the stimulation, the "threshold-impulse-
response" of the EEG generator and the EEG and "f" is the
frequency (cycles per second) (Sato et al. 1957, 1961).

It has also been verified by Sato (1956-57; 1957a, b,
c; 1959a, b) Sato, Ozaki et al. (1960, 1961a) that $G(f)$ is
not only the "frequency response" of the EEG generator, but
also has an extended physiological significance of the "ex-
citability" and assigned as the "transforming action" (Sato,
Mimura et al. 1957, Sato 1956-57, 1957a, b, c, 1958, 1959a, b)
or the "activity" (Sato, Ozaki et al. 1960, 1961).

In addition, Sato (1961, 1962a, b) verified further
physiological significance of the generator "activity"
("transforming action") during performing this research
contract that is equivalent to the "response area" (Galambos
& Davis 1943; Tasaki 1954; Katsuki 1960) in the cerebral
auditory system and the "spectral sensitivity curve" (Suzuki,
Taira and Motokawa 1961) in the cerebral visual system.
That is to say, let "f" in (9.1) be the frequency of the

pure tone stimulus delivered to the ear and be the wave length of the monochromatic light stimulus delivered to eye respectively and in addition let $X_u(f)$ be the threshold stimulus of them, then the frequency-pattern of the excitability of the auditory and/or the visual system can be expressed in the next $E(f)$:

$$(9.2) \qquad E(f) = \frac{1}{X_u(f)} .$$

It is obvious therefore that the "response area" and the "spectral sensitivity curve" are equivalent to $E(f)$. From the above (9.2),

$$(9.3) \qquad X_u(f) \cdot E(f) = 1 \qquad\qquad (1 : \text{unit response})$$

is easily obtained, where "1" in the right side can be considered as the unit amount of the response caused by the threshold stimulus, as often done in physiological experiments. If the stimulation $X(f)$ in (9.1) is equal to the threshold, that is to say, $X(f) = X_u(f)$, then the amount of the response $Y(f)$ can be considered as unity in any frequency, i.e.

$$(9.4) \qquad Y(f) = 1, \qquad \text{when} \quad X(f) = X_u(f),$$

therefore,

$$(9.5) \qquad G(f) = E(f), \quad \text{when } X(f) = X_u(f).$$

Consequently, it is obvious that the "activity" ("transforming action") $G(f)$ has a more extended physiological significance than the "response area" in the auditory system and the "spectral sensitivity curve" in the visual system.

Not only in the peripheral nerve (Gasser 1939), but also in the central nervous system (Lloyed 1946; Jarcho 1949; Chang 1950, 1951; Gastaut et al. 1951) in general, the "excitability cycle" or the "recovery curve" of the excitability is often obtained to make clear its physiological properties.

The concept of the "excitability cycle" is also able to describe in terms of the above noted "activity" (transforming action). When the time-pattern of the "activity" is con-

sidered in terms of the following relationship between the time-pattern of the stimulus intensity and that of the amount of the response, i.e.

(9.6) $\qquad X(t) \cdot A(t) = R(t)$

where $X(t)$ is the strength of the stimulus delivered to a physiological system at time "t" and $R(t)$ is the response of the system elicited by the stimulus $X(t)$ and $A(t)$ is the "activity" of the system to produce the response $R(t)$.

Let the time point, at which the conditioning stimulus will be delivered, be taken as the time origin, then the amount of the evoked response by this conditioning stimulus will be $R(0)$, when 0 is assigned to the time origin. Then the intensity of the conditioning stimulus is able to express by $X(0)$, and the same relation as the equation (9.6):

(9.7) $\qquad X(0) \cdot A(0) = R(0)$

will be able to consider, where $A(0)$ is such an "activity" that the quantitative expression of the physiological property neighbouring the leading electrode(s) to produce the amount of response $R(0)$ by a delivery of the conditioned stimulus $X(0)$. When the test stimulus with the strength $X(t)$ is delivered "t" second later the conditioning stimulus to produce the amount of the response $R(t)$, then the relation (9.6) is also able to consider, where $A(t)$ is the "activity" due to the test stimulus.

The "excitability cycle" is, therefore, nothing else than $R(t)/R(0)$, i.e.

(9.8) $\qquad \dfrac{R(t)}{R(0)} = \dfrac{X(t)\ A(t)}{X(0)\ A(0)}$.

Here, the same conditioning stimulus $X(0)$ is delivered always in its quality and quantity and the test stimulus $X(t)$ is also always constant at any time "t", at which it will be delivered. Then $X(t)/X(0)$ can be regarded as always constant:

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$$(9.9) \qquad X(t)/X(0) = K_X \qquad (K_X : \text{const.})$$

When the amount of the evoked responses by the conditioning stimulus are always finitely constant, as often demonstrated hitherto (Jarcho 1949; Chang 1950, 1951, 1952; Gastaut et al. 1951), then the activity $A(0)$ will be also constant, i.e.

$$(9.10) \qquad A(0) = K_A, \qquad (K_A : \text{const.})$$

The excitability cycle $R(t)/R(0)$ becomes, therefore,

$$(9.11) \qquad \frac{R(t)}{R(0)} = K \cdot A(t),$$

$$(K = K_X/K_A : \text{const.})$$

This result tells us that the "excitability cycle" is nothing else than the time-pattern of the "activity" ("transforming action").

It is already pointed out by Sato, Ozaki et al. (1961a) and Sato (1961, 1962a,b, 1963a,b) that the inverse Fourier transform of the frequency-pattern of the EEG "activity", $G(f)$, in (9.1) is the average time-pattern (autocorrelation function) of the "threshold-impulse-response" of the EEG generator. It would be infered, therefore, that the "activity" ("transforming action") and the "excitability cycle" are analogous each other in their physiological significance. Consequently, an "impulse-response" of the brain in the neighbourhood of the leading electrode(s) and/or the auto-correlogram of the EEG recorded in the resting relaxed state would be resembled each other in their wave form. And some experimental evidences have been demonstrated by Barlow (1960), Uttal and Cook (1962) and Sato (1963a).

An enhancement and diminution in the EEG "activities", which are capable of obtaining in the autocorrelograms of EEGs and/or the crosscorrelograms of the stimulation and the EEGs and their frequency spectra, therefore, will respectively indicate augmentative (or facilitatory) and inhibitory processes in the EEG generator.

Moruzzi and Magoun (1949) observed that not only spontaneous cortical EEG potentials but also recruiting potentials can be abolished by high frequency stimulation to the brainstem reticular formation. Leter, not only Jasper, Naquet and King (1955) confirmed them and but also Purpura (1956) stated that an inhibitory process should have been occured when an electrocortical arousal pattern is evoked by high frequency reticular stimulation, because he could demonstrated depression of the dendritic response in this state. In addition, Steriade and Demetrescu (1960) also demonstrated that high frequency mesencephalic reticular stimulation exerted inhibition of bilateral cortical flicker potential of 1 and 3 /sec, whereas it exerted facilitation of those of 8 and 16 /sec. It was also observed in one of our experimental results (Fig. 7-11) that low frequency flicker potentials in the lateral gyrus were inhibited by high frequency ipsilateral reticular stimulation, whereas they were augmented in the contralateral reticular stimulation. And in the autocorrelograms and their frequency spectra of EEG illustrated in Fig. 7-12, high frequency midbrain reticular stimulation induced reduction of the slow background EEG potentials in average and occasionally enhanced high frequency (25 c/sec) EEG potential. When the slow background EEG potentials were not prominent, they were rather augmented by the reticular stimulation. Further results will be demonstrated in the next FINAL REPORT.

It is generally accepted since Adrian and Matthews (1934) and Adrian and Yamagiwa (1935) stated that diminution or abolishiment of the basic EEG potentials, which is called "electrocortical arousal", indicates an excitatory process in the brain. From the above theoretical and experimental evidences, however, this changes in any EEG potential in men and animals would be followed some inhibitory process informed by depression of EEG potentials, as already state by Purpura (1956), Sato and Mimura (1957) Steriade and Demetrescu (1960) and Mimura et al. (1962).

Marshal (1949), Grüsser-Cornhla and Grüsser (1960) and
Grüsser and Sauer (1960) concluded that no specific inter-
action will take place at geniculate level of cat, while
Bishop and Davis (1953) provided clear evidence that some
interaction did take place at geniculate level. Bishop,
Burke et al. (1958) observed in the excitability cycle in
the geniculate response that the test response in the lateral
geniculate body elicited by the contralateral optic stimulus,
which was delivered various delays after the conditioning
stimulus to the ipsilateral optic nerve, was facilitated and
depressed respectively at intervals of 2-3 ms and 4-300 ms.
Their histoligical studies showed that direct binocular
interaction is limited to the zones in the geniculate nucleus
which contain large cells, i.e., the nucleus interlaminaris
centralis and the nucleus interlaminaris medialis. Although
Grüsser and Sauer (1960) stated no real convergence of both
ipsi- and contralateral retinal afferents could observe,
they observed that 8 neurons showed a statistically signifi-
cant diminution of discharge frequency to synchronous bi-
nocular light stimulation in comparison with their monocular
light responses. This evidence seems to suggest the inter-
action in the geniculate level.

As can be seen in Fig. 7-1A and B, geniculate responses
to binocular rhythmic flash of 10 c/sec were far higher than
the summation of those due to right and left monocular stimu-
lation, so that a conspicous facilitation was yielded in the
geniculate level by repetitive binocular flash stimuli in
every 100 ms. In the excitability cycle demonstrated by
Bishop, Burke et al. (1958) depression of the geniculate
response at the interval of 100 ms between the conditioning
and test stimuls amounted to about 20 %. In addition change
in the discharge frequency of geniculate neurons induced by
synchronous binocular light stimulation was also suggestive
an inhibitory interaction (Grüsser and Sauer 1960). Conse-
quently, an opposite interaction to the result demonstrated

by Bishop, Burke et al. was verified in the average response time- and frequency-patterns of EEG. A new evidences can be expected, therefore, in the frequency response of lateral geniculate body, which will be reported in the next FINAL REPORT, since it takes time to perform data processings necessary for obtaining frequency responses.

Moruzzi and Magoun (1949) noted that low frequency stimulation of the ascending reticular system did not itself induce a recruiting response (Jasper 1949, Jasper and Ajmone-Marsan 1950, Hanberg and Jasper 1953, Verzeano, Lindsley and Magoun 1953, Jasper, Naquet and King 1955), one for each shock which coincode to our EEG response of the stimulating frequency. As illustrated in Fig. 7-13, distinct EEG responses were induced by low frequency stimulation to the midbrain reticular formation. Even when the responses could not observe in the EEG record itself, it was carved in relief in the autocorrelogram of the EEG or in the crosscorrelogram between the stimulation and the EEG. And it was observed such an example as illustrated in Fig. 7-15 that the frequency response in the left lateral gyrus due to contralateral photic flicker stimulation was enhanced by synchronous combination of the ipsilateral midbrain reticular shock stimulation. In the frequency response obtained in the right lateral gyrus the same effect was also observed except at the stimulating frequency of 10 c/sec, at which reduction was observed. In other example of the frequency response in the lateral gyri (Fig. 7-12,F), ipsilateral flicker potentials were augmented by the synchronized electric stimulation to the contralateral reticular formation, while contralateral flicker potentials were inhibited by the synchronized stimulation to the ipsilateral reticular formation. Consequently, it would be obvious that a low frequency reticular stimulation is capable of inducing not only a recruiting response (EEG response), but also of exerting augmentative and/or inhibitory effects upon the cerebral EEG responses. And when an inhibitory

influence is induced by low frequency reticular stimulation
a recruiting response will not appeared.

Doty (1958) confirmed that a cortical strip along the
marginal gyrus adjacent to but probably not within the striate
area yields by far the highest evoked potentials elicited by
optic stimuli.   In comparison with the cortical strip to the
EEG responses to photic flicker stimulation illustrated in
Fig. 7-2 no essential contradictions were observed between
them.

Chang (1950) analysed the complex form of the primary
cortical response of cat to optic nerve stimulation and
demonstrated three independant constituent potentials repre-
senting the activity of three systems of geniculo-cortical
pathways, each of which consists of spike potential and a
slow wave the average time-patterns of EEG response to mono-
and/or binocular flickering stimulation, double or tripple
responses to one flash were observed, each of which was
different in the amplitude and form.   As illustrated in
Fig. 7-2, 7-3, 7-5, 7-6, 7-8, 7-13, 7-18,1 and etc. the re-
sponse were observed also in the lateral geniculate body as
well as in the cerebral cortex to suggest the slow potential
activities of different systems.

It is generally accepted in evoked potential and unit
discharge recorded by gross and microelectrode technique
respectively that contra-lateral eye has a greater represen-
tation than the ipsilateral eye (Doty 1958; Burns, Heron &
Grafstein 1960, Auerbach et al. 1961).   Not only by these
electrophysiological evidences, but by histological fact that
67 % of fibers in a unilateral optic nerve of cat are crossed
(Bishop, Burke et al. 1958), the greater representation of
contralateral eye verified.   In the average time- and fre-
quency-patterns of EEG response illustrated in the paragraph
7, however, some results were coincided to this and others
were opposite to.   In addition, quite a different pattern
was observed between the response elicited by ipsi- and

contralateral monocular stimulation. On the interactions of binocular visual afferents, there would be expected some valuable evidences and arguments on the EEG activities (frequency responses), which will be reported in the next FINAL REPORT.

It would be noted that the frequency responses (Fig. 7-10) induced by monocular flash stimulations in the bilateral posterior sigmoid gyri and bilateral lateral gyri were augmented and inhibited by synchronous combination of the flash and electric shock to right main pad in the stimulating frequency range of 3-7 and 7-11 c/sec respectively, whereas the augmentative effect was not obvious in the contralateral nucleus centrum medianum and ipsilateral lateral geniculate body, though the inhibitory one was observed. There would be able to infer, therefore, such mechanisms from these evidences that inhibitory process induced by cutaneous stimulation in the visual cortex will be followed by the same process as in the thalamic level, which will be related closely to the ascending inhibitory system in the pontine reticular formation (Armengol, Lifschitz and Palestini 1951, Demeterescu and Demeterescu 1962), while the augmentative process will be caused predominantly by the convergence of retinal and cutaneous afferent inflows in the cortical neuron aggregates.

As the normal striate muscle fibers can never excite without extrinsic nervous impulses delivered to their endplates, their tonic activities recorded by the myotonogram (MT) is capable of describing by the same theoretical and experimental points of view of the electroencephalogram, as already reported in THE FIRST QUATARLY PROGRESS REPORT, Paragraph 2. Though some experimental evidences of augmentative and inhibitory midbrain reticular influences were observed (Fig. 7-16A and B; 7-17), further results on the MT "activities" will be reported in the next FINAL REPORT.

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